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ABSTRACT

This student manual on auto service and repair is intended for second-year students in industrial cooperative training who have studied "Automobile Mechanic Fundamentals" during the first year. Based on "Auto Service and Repair," by Martin W. Stockel, this manual is designed for individualized instruction under supervision of a coordinator or instructor. It contains 16 sections that may be studied in any sequence to coordinate the technical information with the training being received on the job. The first assignment, which is about how to use this guide, should be completed first. Each section is composed of from 1 to 12 assignments that follow this format: objectives that tell what the student is to learn for that assignment, identification and location of the assignment in the reference, and exercises to help the student master the objectives. These topics are covered: career opportunities; tools, supplies, and equipment; cleaning parts; function and antifunction bearings; engine service and repair; engine lubrication and ventilation systems; cooling systems; fuel systems; ignition system service; electrical system service; engine tune-up; power train service; suspension service; air-conditioning system service; and exhaust and emission control system service. (YLB)

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Automobile Mechanic Second Year: Service and Repair

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Student's Guide

By
Troy Notgrass

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in cooperation with
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1981

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Contents

Foreword v
Preface vii
A Special Note to the Student ix
Section A. How to Use This Student's Guide 1
A-1: How to Use This Student's Guide 3
Section B. Career Opportunities 5
B-1: Career Opportunities in the Automotive Field 7
Section C. Tools, Supplies, and Equipment 9
C-1: Basic Hand Tools—I 11
C-2: Basic Hand Tools—II 12
C-3: Precision Measuring Tools 13
C-4: Fasteners 14
C-5: Torque Wrenches 15
C-6: Gaskets, Sealants, and Seals 16
C-7: Tubing and Hose 17
C-8: Wire and Wiring 18
C-9: Jacks, Lifts, Pullers, Presses, and Holding Fixtures 19
Section D. Cleaning Parts 21
D-1: Cleaning Equipment and Techniques 23
Section E. Friction and Antifriction Bearings 25
E-1: Friction Bearings 27
E-2: Antifriction Bearings 29
Section F. Engine Service and Repair 31
F-1: Engine Removal 33
F-2: Valves 34
F-3: Valve Guides 35
F-4: Valve Seats 36
F-5: Valve Springs 37
F-6: Mechanical and Hydraulic Valve Lifters 38
F-7: Crankshaft, Main Bearing, and Flywheel Service 40
F-8: Camshaft, Timing Gear, and Chain Service 42
F-9: Servicing Engine Blocks and Cylinders 44
F-10: Piston Service 45
F-11: Ring Service 46
F-12: Rod Service 47
Section G. Engine Lubrication and Ventilation Systems 49
G-1: Engine Lubrication System Service 51
G-2: Ventilation System Service 52
Section H. Cooling Systems 53
H-1: Cooling System Service 55

Section I: Fuel Systems 57
I-1: Fuel Tanks, Fuel Lines, and Fuel Pumps 59
I-2: Carburetor Adjustments 61
I-3: Choke and Anti-stall Dashpot Adjustments 63
I-4: Accelerator Pump, Float, and Other Carburetor Adjustments 64
I-5: Fuel Injection 66
I-6: Diesel Fuel Injection 68
Section J. Ignition System Service 69
J-1: Checking the Ignition Circuit, Coil, and Distributor Cap 71
J-2: Testing and Adjusting the Distributor 72
J-3: Installing the Distributor and Checking Spark Plugs 73
J-4: Checking the Ignition System with an Oscilloscope 74
Section K. Electrical System Service 75
K-1: Checking and Servicing the Battery 77
K-2: Checking and Servicing DC Generators 79
K-3: Checking and Servicing AC Generators 81
K-4: Checking and Servicing Regulators 83
K-5: Starter System Service 85
Section L. Engine Tune-up 87
L-1: Engine Tune-up 89
Section M. Power Train Service 91
M-1: Clutch Service 93
M-2: Manual Transmission Service 95
M-3: Overdrive and Four-Wheel Drive Service 97
M-4: Automatic Transmission Checks 99
M-5: In-Car Transmission Repair 100
M-6: Transmission Removal 102
M-7: Propeller Shaft and Universal Joint Service 103
M-8: Troubleshooting and Disassembling the Axle and Housing 105
M-9: Differential Disassembly and Repair 107
Section N. Suspension Service 109
N-1: Brake System Operation 111
N-2: Repairing Drum Brakes 113
N-3: Repairing Disc Brakes 115
N-4: Wheel Alignment 116
N-5: Front Wheel Bearings 118
N-6: Tire Service 120
N-7: Manual Steering Systems 121
N-8: Power Steering Systems 123
N-9: Steering Linkage 125
Section O: Air-Conditioning System Service 127
O-1: How Air Conditioning Works 129
O-2: Air-Conditioning Service 131
Section P. Exhaust and Emission Control System Service 133
P-1: Exhaust and Emission Control System Service 135

Foreword

This publication is one of a series developed by the Center for Occupational Curriculum Development for students in industrial cooperative training. The material is designed so a student can work at his or her own pace, learning things that best meet specific needs. The material is also designed so that work experience on the job can be related to information studied at school.

Although the material is for individualized study, it should be used under the supervision of a coordinator or instructor. For that reason, two basic publications are offered—a student's guide and a coordinator's guide.

The *student's guide* is designed for the person in training. It includes the identification and location of the assignment in the reference, objectives that tell what the student is to learn for each assignment, and exercises to help the student master the objectives.

The *coordinator's guide* has additional information that will aid the coordinator in helping the student. There are suggestions on how the student should use the student's guide and how the instructor can coordinate work experience and learning at school. As needed, there is further information on how to help students achieve related skills in mathematics, reading and communication, and principles of science. These pages are not in every guide. They are written to fit each occupational situation. The coordinator's guide also features (1) answers to both exercise questions and assignment tests, (2) one set of assignment tests, and (3) work sheets that the coordinator can conveniently use to match job experience and related instruction for each student.

Although both the student's guide and the coordinator's guide are copyrighted, the coordinator should feel free to reproduce copies of the assignment tests and the coordinating work sheets. To make that possible, tests and work sheets have been placed in a separate section of the guide, where they are readily accessible for copying. If the coordinator prefers, these same sheets may be ordered separately for individual students from the Center for Occupational Curriculum Development, P.O. Box 7218, The University of Texas at Austin, Austin, Texas 78712.

Jack E. Robertson, Director
Center for Occupational Curriculum
Development

Preface

This student's guide was developed for second-year students who have studied *Automobile Mechanic Fundamentals* during the first year in the co-op program. It is based on a single reference, *Auto Service and Repair,* by Martin W. Stockel, published by Goodheart-Willcox in 1978.

The sections in this student's guide may be studied in any sequence in order to coordinate the technical information with the training being received on the job. However, to gain the most from the reference, you should study the assignments within each section in numerical order.

A Special Note to the Student

The assignments in this student's guide are designed to help you learn. You will gain more from the material if you know how to work the assignment. For that reason, Assignment A-1, which is about how to use this guide, should be completed first.

Section

A

How to Use This Student's Guide

A-1: How to Use This Student's Guide

A-1

How to Use This Student's Guide

Objectives: *After completing this assignment, you will be able to –*

1. *state the primary concern of the author when developing the guide;*
2. *name the four parts into which each assignment is organized;*
3. *explain the purpose of the objectives;*
4. *explain why the technical information should be read before answering the exercise questions:*
5. *state the reason for working the exercise questions; and*
6. *explain the importance of the assignment test.*

You, the student, might be surprised if you knew how closely your interest in this student's guide and that of the author compare. For instance, did you know that the author's first concern was to make learning as easy as possible? In fact, the organization of this guide has been based on how to make the information in each assignment easy to learn and yet stay in your mind. Each assignment has four parts: (1) the learning *objectives* of the assignment, (2) the *technical information,* (3) the *exercise,* and (4) the *assignment test.* Studied in this order, this arrangement should provide you with the greatest learning opportunity.

To illustrate, go back—right now—and reread the objectives. Had you really paid any attention to the objectives the first time you read them? Or did you even read them? They are important since they tell you what you should be able to remember after completing this assignment. You read the objectives so you will know what important information to look for. Then, as you read, things you need to know will literally pop up in your mind's eye. A short assignment test has been written for each assignment. The questions test the very information the objectives said was important to learn.

Be sure to read the objectives first, the technical information second, and then answer the questions in the exercise. This arrangement has a purpose. First, you learn what to look for when reading. Then you read and learn all the information required for mastering the lesson. The only reason for the open-book type of exercise is to guide your mind for the third time over the facts considered important.

If you are in a co-op class, your notebook should show anyone what you have studied during the one or two years you have been in this program. Since this is true, the following rules may be useful in answering the exercise questions. Of course, the teacher-coordinator may have an official set of class rules. If such is the case, by all means follow them.

1. All work should be done on regular two-, three-, or five-hole theme paper—never on spiral notebook paper.

2. Either (a) write the answers in complete sentences or (b) write the question and then write only the answer on the line below.

3. VICA members are supposed to do their work in their own handwriting if it is to be entered in competition.

4. For your own benefit, include a correction sheet in your notebook. You can write down the correct answers after your teacher-coordinator has checked the exercises.

A word of caution in working exercises. *Do not hurry through the questions.* Take your time, and learn each assignment as you go. Your teacher-coordinator is not interested in *how many assignments* you turn in. Your teacher's main concern is *how much you have learned.* Just stay busy, do your work, and let the number of assignments turned in take care of themselves.

If you study the assignments as instructed here, the fourth part—the test—will be a snap. That is because you will have covered the information three times before taking the test. The test is based on information given in the objectives.

If you do not do well on the test, go back to the objectives and study the assignment over again. After completing the objectives, the technical information, and the exercise, ask your teacher-coordinator to retest your knowledge. If you still do not do well, perhaps the author should redo the assignment. This goes back to the first statement that your interest in this guide is the same as that of the author. You see, if you fail to learn, the author, through this guide, has failed to teach.

Exercise:

1. How does your interest in this manual and that of the author compare?
2. List the four parts of each assignment, which are designed to make learning easy.
3. What makes the objectives important?
4. Of what secondary importance are the objectives?
5. Give the proper sequence or order of study so that you can learn the most from an assignment.
6. What is the purpose of studying the assignment in the proper sequence?
7. Why is the kind of paper you use and the way you answer questions of importance?
8. If your teacher-coordinator is not particularly interested in how many assignments you study, what is the teacher's main concern?
9. Why should the short test be snap?

Section

B

Career Opportunities

B-1: Career Opportunities in the Automotive Field

B-1

Career Opportunities in the Automotive Field

Objectives: *After completing this assignment, you will be able to—*
1. explain the types of jobs available in the industry;
2. explain the working conditions;
3. explain the salary range; and
4. explain how to get more schooling in automobile mechanics.

Reference: Martin W. Stockel, *Auto Service and Repair* (South Holland, Ill.: Goodheart-Willcox Co., 1978), pp. 817-820.

Exercise:

1. What tasks are involved in the job of cleaning a car?
2. How does cleaning cars offer opportunities for advancement?
3. What tasks are involved in the lubrication of a car?
4. What kind of work does a light-repair mechanic do?
5. What kinds of jobs will a heavy-repair mechanic do?
6. Under what conditions does a beginning mechanic generally start?
7. Why are mechanics becoming more specialized in the automotive field?
8. What jobs will a tune-up specialist do?
9. What special skills does a transmission specialist need?
10. What is the duty of a front-end specialist?
11. What jobs does an electrical specialist handle?
12. How is the shop supervisor's time spent in a large shop?
13. What does a shop supervisor in a small shop do that a supervisor in a large shop does not do?
14. What is the responsibility of the service manager?
15. Briefly describe the kind of work a service manager does.
16. What personal qualities should a service manager have?
17. Describe a modern garage.
18. Where is most of the mechanic's work done?
19. What factors influence the salary a mechanic can expect?
20. In general, how do the salaries of most mechanics compare with those in other technical occupations?
21. What factors indicate that you would be satisfied in the automobile mechanic field?
22. Where can you learn the automobile mechanic trade after you get out of high school?

Section

C

Tools, Supplies, and Equipment

C-1: Basic Hand Tools–I
C-2: Basic Hand Tools–II
C-3: Precision Measuring Tools
C-4: Fasteners
C-5: Torque Wrenches
C-6: Gaskets, Sealants, and Seals
C-7: Tubing and Hose
C-8: Wire and Wiring
C-9: Jacks, Lifts, Pullers, Presses, and Holding Fixtures

C-1

Basic Hand Tools–I

Objectives: *After completing this assignment, you will be able to –*
1. explain why only quality tools should be purchased;
2. explain how to determine if tools are in fact quality tools; and
3. explain how to use hand tools properly.

Reference: *Auto Service and Repair,* pp. 7-16.

Exercise:

1. Why can a mechanic not afford to waste time working with an inadequate selection of tools?
2. What metal is used to make top-quality tools?
3. List four reasons why quality tools should be purchased rather than less expensive ones.
4. Why is it important to you to keep your tools clean and orderly?
5. What is the ball peen hammer used for?
6. What are chisels used for?
7. What personal safety equipment should you wear when using a chisel?
8. What are starting punches used for?
9. What are center punches used for?
10. What are aligning punches used for?
11. What safety precaution should you take before using a file?
12. Which is the cutting stroke when filing?
13. What can be used to help prevent a file from clogging?
14. How is a rotary file powered?
15. What do mechanics commonly use bench or pedestal grinders for?
16. Which parts of the body should be protected from the effects of a grinder?
17. Where should the tool rest be set when it is used on a grinding operation?
18. What should be used to hold small objects when grinding them?
19. Why should you never strike a grinding wheel while it is revolving?
20. What is a good maintenance characteristic of twist drills manufactured of high-speed steel?
21. Why should you ease up on the pressure just before the drill breaks through the stock?
22. What are reamers used for?
23. What is the difference between the uses of taps and dies?
24. What is used to lubricate taps and dies during use?
25. What are hacksaws used for?
26. What kind of jaws should be used in a vise to prevent damage to the work?
27. What safety device should be used when operating a wire wheel or cleaning with caustic solutions?

C-2

Basic Hand Tools—II

Objectives: *After completing this assignment, you will be able to—*
1. name the types of screwdrivers, pliers, and sockets and
2. explain the purposes of the different kinds of wrenches.

Reference: *Auto Service and Repair,* pp. 16-24.

Exercise:

1. What are four types of screwdrivers?
2. What kind of work should you avoid doing with a screwdriver?
3. Name eight types of pliers.
4. What are the advantages of the 12-point and 6-point openings on box wrenches?
5. On what jobs is the flare nut wrench an invaluable tool?
6. What is the disadvantage of using an open end wrench?
7. With what sizes of drives are sockets available?
8. What is the advantage of a swivel socket?
9. Name five kinds of handles used with sockets.
10. What is the advantage of using a flex-head wrench?
11. Why should you use a wrench other than an adjustable one if possible?
12. What is the pipe wrench used for?
13. What is the advantage of using power or impact wrenches?

C-3

Precision Measuring Tools

Objectives: *After completing this assignment, you will be able to—*
1. explain how to care for measuring instruments and
2. explain how to use the various measuring instruments.

Reference: *Auto Service and Repair,* pp. 25-38.

Exercise:

1. What can be the result of a careless or inaccurate measurement?
2. What factors other than cost should you consider when buying measuring tools?
3. How is a measuring tool properly cleaned for storage?
4. What kinds of parts are measured with an outside micrometer?
5. How far will each turn of the thimble of a micrometer move the spindle?
6. Why should you always clean the work to be measured by a micrometer?
7. Between which two parts of the micrometer is an object placed for measurement?
8. How much force should be used to slip an object being measured through the micrometer?
9. Why should you rock the micrometer back and forth over the work after the measurement has been taken?
10. What is the purpose of a dial gauge or indicator?
11. Under what conditions are calipers used?
12. What are dividers used for?
13. What are feeler gauges used for?
14. What is an accurate steel straightedge used for?

C-4

Fasteners

Objectives: *After completing this assignment, you will be able to–*

1. *describe machine screws, sheet-metal screws, bolts, nuts, and studs;*
2. *explain where each of the fasteners is used;*
3. *name the different types of nuts; and*
4. *describe the characteristics of bolts.*

Reference: *Auto Service and Repair,* pp. 39-48.

Exercise:

1. Why are fasteners and torque settings more important now than they have been in the past?
2. Distinguish between machine screws and bolts.
3. Why is a punched hole better than a drilled hole when using sheet-metal screws?
4. Describe a stud.
5. List the five methods of removing broken studs, shown in figure 3-6A in the text.
6. What can be done to make it easier to remove a broken stud or screw regardless of the method used?
7. Name three ways to repair a hole in which the threads are beyond repair.
8. Name five common automotive nuts.
9. Name the nine characteristics of bolts used to identify them.
10. Why is the coarse thread used more often than the fine thread?
11. What causes nuts to work loose if a locking device is not used?
12. Name three types of self-locking nuts.
13. What are keys, splines, and pins used for?
14. What are snap rings used for?
15. What are setscrews used for?
16. When are pop rivets used?

C-5

Torque Wrenches

Objectives: *After completing this assignment, you will be able to—*

1. *explain the nine factors that affect torquing a bolt or nut;*
2. *explain how tight to torque a bolt;*
3. *explain how to find a bolt's tensile strength by looking at the head;*
4. *explain how to read the amount of torque exerted on a torque wrench; and*
5. *explain how to use a torque wrench.*

Reference: *Auto Service and Repair,* pp. 48-57.

Exercise:

1. Define the following terms:
   a. torque
   b. tension
   c. elastic limit
   d. distortion
   e. tensile strength
   f. residual tension
   g. elasticity
   h. compression
   i. cold flow
   j. Hooke's Law
2. What are the requirements of properly fastening parts together?
3. List seven negative things that could happen if a mechanic were to completely assemble an engine without knowing how much torque was applied to each nut or bolt.
4. How can you find the correct torque specifications on a particular nut or bolt?
5. Generally, how tight should a fastener be tightened?
6. How can you determine the tensile strength of a bolt or screw?
7. State the law around which the torque wrench is designed.
8. What is the purpose of the light and audible sensing devices on torque wrenches?
9. What two scales are generally used on torque wrenches?
10. How can you increase the range of a torque wrench?
11. In what range will a torque wrench produce best results?
12. Why must the threads be absolutely clean and free of rust, carbon, etc., when torquing?
13. How will the use of a high-pressure lubricant on the threads affect the ability of a nut or screw to remain at the proper torque?
14. In what sequence should fasteners be tightened where a number of fasteners are used and no sequence chart is available?
15. Give the procedure for torquing.
16. How should you grip the handle of a torque wrench?
17. How does a noticeable amount of run-down affect the torque specifications?

C-6

Gaskets, Sealants, and Seals

Objectives: *After completing this assignment, you will be able to—*

1. *explain the purpose of gaskets, sealants, and seals;*
2. *explain how to use gaskets;*
3. *explain how to use sealants;*
4. *explain how to torque a series of bolts; and*
5. *explain how to install a seal correctly.*

Reference: *Auto Service and Repair,* pp. 59-72.

Exercise:

1. What functions do gaskets serve?
2. What materials are used to make gaskets?
3. What determines the type of material used to make a specific gasket?
4. Why should a gasket not be reused?
5. What should the mating surfaces be checked for?
6. How does the presence or absence of moisture affect paper and cork gaskets?
7. What conditions should you beware of when selecting a gasket?
8. What conditions make it necessary to use a sealant on most gaskets?
9. Where can sealants not be used?
10. Why is it generally worse to use too much sealer than none at all?
11. How can a gasket be held in place to install if a sealant is not used?
12. What is the proper sequence for torquing each of several fasteners?
13. Why is it necessary to use care when tightening fasteners of stamped parts?
14. What can oil seals be used for?
15. Why should a sealer be used sparingly when installing an oil seal?
16. Why is it important to never strike the inner portion of a seal?
17. Why are even little leaks important?

C-7

Tubing and Hose

Objectives: *After completing this assignment, you will be able to—*
1. name the types of materials used to make tubing;
2. explain the advantages of the various types of tubing;
3. identify the correct tools used to work with tubing; and
4. explain how to install hoses.

Reference: *Auto Service and Repair,* pp. 73-89.

Exercise:

1. What kinds of tubing are used on automobiles?
2. What are the good characteristics of copper tubing?
3. What are the advantages of double-wall construction steel tubing?
4. What are the advantages of plastic tubing?
5. Why should tubing not be placed flat and pulled from the roll?
6. What is the best tool for cutting tubing?
7. Describe a correctly flared tube.
8. What tool is most often used to bend soft copper and thin-wall steel tubing?
9. What conditions should you try to avoid when bending tubing?
10. Why should straight runs of tubing be avoided?
11. Why should long runs be supported?
12. Where *must* flared fittings be used?
13. Where may compression fittings be used?
14. Where will a long compression or flare nut be used?
15. What is the purpose of the tapered threads of pipe?
16. How many turns with a wrench should you make to tighten a pipe joint?
17. What is the purpose of an O ring?
18. What is used to prevent water hoses from collapsing?
19. What conditions should you avoid when installing hoses?
20. What is the minimum radius you should make in a hose bend?
21. What conditions indicate that a hose should be replaced?

C-8

Wire and Wiring

Objectives: *After completing this assignment, you will be able to—*

1. *explain the location of the primary and secondary circuits;*
2. *name the types of conductors used in the electrical system;*
3. *explain how the size and length of wire affect the flow of electrons;*
4. *name the kind of solder used on electrical connections; and*
5. *explain why fuses are located as close to the source as possible.*

Reference: *Auto Service and Repair,* pp. 93-104.

Exercise:

1. What voltage does the primary wiring handle?
2. Where is the secondary wire used?
3. Why is soft copper wire widely used for stranding?
4. What materials are being used for secondary wire stranding?
5. What are the advantages of using plastic as an insulator?
6. What is a terminal block used for?
7. What is a junction block used for?
8. What are the advantages of using a wiring harness?
9. What factors determine the correct wire gauge or size?
10. How does the length of the wire affect the resistance?
11. How is the total load figured if the load will fluctuate?
12. How is the electrical load imposed on a wire determined?
13. What are the two ways of attaching terminals?
14. How much insulation should be stripped when installing a terminal?
15. What type of solder should be used to solder terminals?
16. Why is it important to choose a terminal shaped so that the wire will not bend sharply when snapped on the plug?
17. Where are the slide and bullet-type connectors used?
18. Which areas of the vehicle should you keep wiring away from?
19. What is used to protect the wire where it passes through sheet metal?
20. Why should a fuse be placed as close as possible to the electrical source?
21. What is the advantage of using a printed circuit?
22. What are some conditions that cause problems in wiring?

C-9

Jacks, Lifts, Pullers, Presses, and Holding Fixtures

Objectives: *After completing this assignment, you will be able to—*
1. explain the uses of the tools and equipment discussed in this assignment and
2. explain the safety rules for using these tools and equipment.

Reference: *Auto Service and Repair,* pp. 107-116.

Exercise:

1. What kinds of duties can the hand jack perform?
2. What uses can be made of a hydraulic floor jack?
3. What parts of a car should you never use to jack up a car?
4. What should support the weight of a vehicle before you get under it to work on it?
5. What should you take into consideration when thinking about using an end lift?
6. Which feature of an end lift makes it possible to work under a car without using jack stands?
7. List the ten safety considerations to keep in mind when using lifts.
8. List nine safety rules to observe when using a crane or chain hoist.
9. Where can extension jacks be used effectively?
10. What makes a hydraulic press superior to striking tools when removing bearings, etc?
11. List seven safety precautions to follow when using hydraulic equipment.
12. List three types of pulling jobs.
13. What precaution should be observed when using a repair stand?
14. List six rules to remember when hand lifting heavy or bulky objects.

Section

D

Cleaning Parts

D-1: Cleaning Equipment and Techniques

D-1

Cleaning Equipment and Techniques

Objectives: *After completing this assignment, you will be able to—*
1. explain how to clean parts in each of the methods discussed and
2. explain the safety rules involved in each of the methods of cleaning parts.

Reference: *Auto Service and Repair,* pp. 139-146.

Exercise:

1. Why is it important to clean auto parts carefully?
2. What kinds of parts are cleaned with wire brushes and scrapers?
3. Where should a power brush never be used?
4. List fourteen safety rules for handling cleaning solutions.
5. Why should parts placed on a tray in a solvent tank be placed with the hollow areas up?
6. What should you do with parts that may rust after they have been cleaned?
7. What are "hot tanks" usually used for?
8. What should be done to parts that are subject to rusting after being cleaned in a hot tank?
9. How do you know when to ignite the burner of a steam cleaner?
10. Which parts of an engine should be protected from a steam cleaner?
11. Why should the steam be wet?
12. List eight safety rules for steam cleaning.
13. How much pressure may be at the nozzle of high-pressure cleaners?
14. Why should you never use a low flash point solvent in a spray cleaner?
15. How are odors and evaporation controlled in cold soak-cleaning solutions?
16. Which part of the automobile is most often sandblasted?

Section

E

Friction and Antifriction Bearings

E-1: Friction Bearings
E-2: Antifriction Bearings

E-1

Friction Bearings

Objectives: *After completing this assignment, you will be able to—*
1. explain what a friction bearing is;
2. explain the function of bearing clearance:
3. explain how dirt affects the engine; and
4. explain how operational faults affect the bearing life.

Reference: *Auto Service and Repair,* pp. 149-160.

Exercise:

1. Distinguish between friction and antifriction bearings.
2. What development made babbitted bearings obsolete?
3. Explain the basic construction of precision insert bearings.
4. What is the purpose of a thrust flange?
5. How is a bearing correctly forced into place?
6. What is the purpose of providing bearing crush?
7. Which part of the insert prevents it from turning in place?
8. Why is it important to keep the bore halves in the same position after replacing inserts as they were before they were removed?
9. Why is it important to use the correct size socket when tightening bolts or nuts on bearing caps?
10. What can cause the block to become distorted?
11. What kinds of passages are incorporated into the insert to permit oil to enter freely?
12. Why must there be a clearance between the bearing and the shaft?
13. What is the most widely used method of checking bearing clearance?
14. How does the construction of a camshaft bearing differ from a crankshaft bearing?
15. How are bushings usually installed?
16. Which part of a shaft is the journal?
17. How smooth should the surface finish of bearing journals be?
18. How long will a bearing last if it is of the correct size and type, is installed in an accurate bore, and operates against a smooth, round shaft?

19. Why does the oil pressure drop prior to bearing failure?
20. What is the number one cause of bearing failure?
21. What does the word *dirt* include?
22. Name three conditions that will cause bearing lubrication failure.
23. What are four sources of dirt in the engine?
24. Name six operational faults that will cause bearing failure.

28

E-2

Antifriction Bearings

Objectives: *After completing this assignment, you will be able to–*
1. explain how antifriction bearings work;
2. explain the kinds of loads that bearings must handle;
4. explain the safety precautions for removing, cleaning, and installing bearings; and
5. explain how to prepare the bearing housing bore and shaft before installing the bearing.

Reference: *Auto Service and Repair,* pp. 163-176.

Exercise:

1. Explain how antifriction bearings work.
2. Name the three types of antifriction bearings.
3. What kinds of loads are antifriction bearings designed to handle?
4. Distinguish between radial and thrust loading designs.
5. Name the conditions that affect the type of bearing installed.
6. Name the kind of load each of the following type of bearings is designed to handle.
   a. straight roller
   b. spherical roller
   c. tapered roller
   d. deep groove ball
   e. angular contact ball
   f. multiple row bearing
7. When would self-aligning bearings be used?
8. How are bearings marked for easy identification?
9. Generally, how are bearings best removed?
10. What will the results probably be if a bearing is pulled or installed by exerting force on the free ring?
11. Explain how a bearing puller works that is designed to remove tapered roller bearings when the inner ring cannot be grasped.
12. List eight general rules for bearing removal.
13. Why should a shield be used whenever possible when pulling a bearing?
14. Why should you never clean bearings with volatile fluids or carbon tetrachloride?
15. Why should you never spin a bearing with air pressure?

16. Name the seven most common types of bearing defects.
17. How do you check for wear when new bearings often feel rather loose?
18. What should you do if only a single part of the bearing is damaged?
19. What should you do to the bearing immediately after inspection?
20. How should all grease and oil be stored when not in use?
21. How should bearing housing bores and shafts be prepared before installing the bearing?
22. List thirteen general rules for bearing installation.

30

Section

F

Engine Service and Repair

F-1: Engine Removal
F-2: Valves
F-3: Valve Guides
F-4: Valve Seats
F-5: Valve Springs
F-6: Mechanical and Hydraulic Valve Lifters
F-7: Crankshaft, Main Bearing, and Flywheel Service
F-8: Camshaft, Timing Gear, and Chain Service
F-9: Serving Engine Blocks and Cylinders
F-10: Piston Service
F-11: Ring Service
F-12: Rod Service

F-1

Engine Removal

Objectives: *After completing this assignment, you will be able to—*

1. name the parts that should be disconnected when removing an engine;
2. explain how to prevent losing fasteners while working on the engine;
3. explain how to mark wire for easy identification; and
4. explain the safety rules for removing an engine.

Reference: *Auto Service and Repair,* pp. 179-182.

Exercise:

1. What is the purpose of scribing around the hinge before removing the hood?
2. Why are the battery and radiator removed from the vehicle?
3. What procedure should be used to identify wires so they can be replaced correctly?
4. Which part of the fuel system should be disconnected?
5. What should you do to prevent dirt from entering the cooling system?
6. What do you do with fasteners once the part they are holding is removed?
7. Why should you never use the head cap screws to attach the puller brackets without shimming to force the strap against the block?
8. Why is it important that the proper balance point be selected?
9. Why is it important to make certain that the pull point will not slip under pressure?
10. What should you do, as you lift the engine, to be certain that the engine is free?
11. What should you do after the engine has been raised to a height sufficient to clear the vehicle?
12. List eight safety rules for pulling an engine.

F-2

Valves

Objectives: *After completing this assignment, you will be able to—*
1. explain the proper procedures for removing the cylinder heads, rocker arm assembly, and pushrods;
2. explain how to grind the valves; and
3. explain how to determine when to discard worthless valves.

Reference: *Auto Service and Repair,* pp. 185-191.

Exercise:

1. Why should you never remove a cylinder head until the engine has cooled?
2. Give the proper procedure for removing a rocker arm assembly.
3. Give the procedure for removing ball stud type rocker arms.
4. Give the proper procedure for removing the pushrods.
5. Give the correct procedure for removing the cylinder head.
6. What should you avoid doing if the cylinder head is stuck?
7. Where should valves be placed when they are removed?
8. What conditions should you look for when you inspect the valves?
9. How are valves cleaned?
10. What are the most common angles at which valves are ground?
11. What will happen if too much of the valve protrudes from the chuck?
12. What condition indicates that a valve is warped enough that it should be discarded?
13. Explain the procedure for grinding after the machine has been set.
14. What should you do if you turn the stone feed wheel the wrong way too fast and jam it against the valve?
15. Why should you remove the same amount from the stem as you removed from the valve face?
16. Why should you not remove more than .010 inch from the valve stem?
17. What is the purpose of the margin?
18. How should the valve be treated after it has been ground and passed inspection?

F-3

Valve Guides

Objectives: *After completing this assignment, you will be able to—*
1. name the problems caused by excessive valve guide clearance;
2. explain how removable and integral valve guides are repaired;
3. name the forces that cause oil to flow through intake valve guides; and
4. explain the methods used to prevent oil from flowing through intake valve guides.

Reference: *Auto Service and Repair,* pp. 191-196.

Exercise:

1. What is a good way to remove carbon from the combustion chambers and valve ports?
2. What should you use to clean the head-to-block surface?
3. What kinds of problems will excessive valve stem clearance cause?
4. What are the two ways of checking for valve stem to guide clearance?
5. How are worn integral guides repaired?
6. How may valve guides be removed?
7. Why does it help to put a valve guide in a refrigerator or freezer before installing it?
8. How can you measure the correct depth to drive in the valve guides?
9. In which direction should the reamer be turned while entering and leaving the guide?
10. What guides the reamer through the guide?
11. How is an integral guide prepared to receive a special oil seal?
12. What causes oil to pass through the intake guide during the intake and exhaust strokes?
13. Name the forces that attempt to draw oil down through the guides.
14. What kinds of methods are used to prevent oil from flowing down the stem to the guide?

F-4

Valve Seats

Objectives: *After completing this assignment, you will be able to–*
1. explain the conditions a valve seat should be checked for;
2. name the two types of valve seats;
3. describe the correct and incorrect conditions for a newly ground valve seat; and
4. list the angles at which valve seats are ground.

Reference: *Auto Service and Repair,* pp. 196-205.

Exercise:

1. What conditions should the valve seats be checked for?
2. How are insert and integral valve seats repaired?
3. What is used to remove valve seat inserts?
4. Which measurements of a new insert must match those of the old insert?
5. How do you know what type of insert to replace an insert with?
6. What is used to install valve seats?
7. How does the OD of the seat insert compare to that of the recess into which it fits?
8. What is the purpose of making the insert OD greater than that of the recess?
9. Which inserts must be peened or swaged?
10. How do you determine the exact depth for a recess cutter tool to cut so the insert will fit exactly?
11. How is the cutter fed into the work?
12. Describe a correctly installed valve seat.
13. What problems will result from a seat being too narrow?
14. What problems will result from a seat being too wide?
15. What are the two basic types of stone pilots?
16. Why should you mount the correct angle stone on one sleeve and the 15-degree and 70-degree stones on two other sleeves before you start?
17. What is the correct procedure for grinding a seat?
18. Why should you be careful to remove only enough stock to clean the seat?
19. Why should you cut with the 60-70 degree stone for only two seconds?
20. What is the purpose of putting soft pencil marks across the width of the 30 degree or 45 degree angle?
21. What is the specified tolerance allowed for valve seat concentricity?
22. What colors are used to check the concentricity of the valve seat and face?
23. What should be done if a rocker arm stud is loose?

F-5

Valve Springs

Objectives: *After completing this assignment, you will be able to–*

1. *explain how to clean valve springs;*
2. *explain how to check valve springs for soundness;*
3. *explain how defects affect engine operation;*
4. *explain how to check the cylinder head for defects; and*
5. *explain how to bring the cylinder head to proper torque.*

Reference: *Auto Service and Repair,* pp. 205-210.

Exercise:

1. How should valve springs be cleaned?
2. What should not be used to clean valve springs?
3. Why should spring tension be checked during an overhaul?
4. What should you check with a combination square?
5. What conditions should you check the valve springs for?
6. What conditions indicate the springs should be discarded?
7. What will a weak spring cause?
8. What is the maximum allowable warpage in a cylinder head for each 6 inches?
9. How is a warped cylinder head repaired?
10. What tool is used to check a cylinder head for warpage?
11. Why is it important to check the height of the valve stem from the head on some engines?
12. How are the coil springs and the damper spring usually positioned in relation to each other?
13. What is used to hold the valve springs and valve stem together?
14. Name the parts of a typical valve spring assembly.
15. Under what conditions would you install a valve in a port other than the one from which it was removed?
16. What is used to correct the height of the valve stem keeper groove when the valve face and seat have been ground?
17. How does the procedure for installing ball joint rocker arms differ from installing rocker shaft and arm assembly?
18. What can be used for guide pins if the cylinder head does not have built-in guide pins?
19. What should you check about the cylinder head gasket before installing it?
20. How much cement should be used on the gasket?
21. How should head cap screw threads be treated before being installed?
22. What is the proper procedure for torquing a cylinder head?
23. What machine is used to grind the rocker arm?
24. How is the rocker arm end curve maintained?

F-6

Mechanical and Hydraulic Valve Lifters

Objectives: *After completing this assignment, you will be able to—*
1. explain the conditions that affect the operation of valve lifters;
2. explain the construction of hydraulic valve lifters;
3. explain how to check the operation of valve lifters;
4. explain the procedure for installing valve lifters; and
5. explain the amount of lash provided by mechanical and hydraulic valve lifters.

Reference: *Auto Service and Repair,* pp. 211-221.

Exercise:

1. Describe the condition a mechanical lifter should be, to be reused.
2. What is the maximum amount of material that can be removed from the end of a mechanical lifter?
3. What is the procedure for getting a smooth finish?
4. What often makes it difficult to remove lifters?
5. How are the lifters kept in the same order as they were before they were removed?
6. Why are the plunger and body of automatic lifters selectively fitted?
7. Why is it extremely important that the hydraulic valve be assembled in spotless conditions?
8. What determines the length of time the valve lifters are left in the cleaning solvent?
9. What kind of cloth is used to wipe the valve lifters?
10. How are the valves dried?
11. What size scratches make a valve lifter useless?
12. Describe the condition of a hydraulic lifter that can be reused.
13. Which conditions are cause for rejecting a ball retainer?
14. Why do some garages discard the entire assembly when only one part of the valve assembly is worn?
15. What is the procedure for inspecting and assembling the hydraulic valve lifters?
16. Explain the procedure for assembling a hydraulic lifter.
17. What is meant by leakdown rate?

18. How are the valve lifters filled with oil for installation?
19. How should the valve lifters be filled with oil if they are not filled before installation?
20. What positioning precautions should be taken when installing rocker arms on the shaft?
21. What additional function do some rocker arm shaft support brackets serve?
22. What are the advantages of positioning the rocker oil passages so that they face toward the head?
23. How are individual ball stud rocker arms lubricated?
24. Why must the bracker cap screws be tightened slowly?
25. What is the purpose of adjusting hydraulic lifters by using pushrods of varying lengths?
26. How can it be determined when the lifter is resting on the base circle when the camshaft cannot be seen?
27. Where should the plunger be in its stroke when the lifter body is on the cam base circle?
28. How much lash should there be when the lifter body is on the cam base circle?
29. What will result from not having enough clearance on mechanical lifters?
30. What kind of drag on a feeler gauge indicates that the valve setting is correct?
31. What is used to hold a valve in place when a new valve spring or valve guide seal needs to be installed with the cylinder head in place?

F-7

Crankshaft, Main Bearing, and Flywheel Service

Objectives: *After completing this assignment, you will be able to—*
1. explain the conditions that indicate that a crankshaft should be repaired;
2. explain how to repair a crankshaft;
3. explain how to remove and install inserts; and
4. explain how to remove and install ring gears on flywheels.

Reference: *Auto Service and Repair,* pp. 225-239.

Exercise:

1. Why should a main bearing cap never be marked on top of the cap?
2. What should be avoided when removing main bearing caps?
3. Explain the procedure for checking the main bearing bores for out-of-roundness.?
4. What indicates that the bores are out of alignment when using an alignment bar?
5. What is used to clean out the oil channels of a crankshaft?
6. What is used to remove the carbon and gum deposited on the crankshaft where the oil groove fits?
7. Other than the finish, what should be checked about the crankshaft?
8. Where on the journal should the measurement be made?
9. Why should you not use the smallest or average of all measurements when selecting an insert size?
10. Why do connecting rod journals tend to wear more out-of-round than main bearing journals?
11. How is the amount of material to be removed from all related journals determined?
12. Name three ways of building up damaged journals.
13. How should a crankshaft be treated after it has been ground and polished?
14. Why is it important to get the halves of the inserts in the correct halves of the journal?
15. What is indicated when the Plastigage is wider at one end than the other after torquing?
16. How should an asbestos, graphite impregnated wick be treated before it is installed?
17. What is used to press the oil seal into the groove fully?
18. What is the procedure for cutting the oil seal to length?
19. What precaution should be taken when installing synthetic seals that use special glue?

20. What should you do after running the stud bolts up snugly but before tightening them to torque?
21. To which end of some crankshafts are shims added to adjust end play?
22. List the procedure for removing an insert while the engine is in place, using a removal plug.
23. What is the purpose of using an extension jack when checking main bearing clearance with the engine in place?
24. What is used to install a wick-type upper seal at the rear journal when the engine is in place?
25. Which conditions indicate that the face of a clutch disc should be reground?
26. Name three methods of attaching the ring gear to the flywheel.
27. How is the temperature of the ring gear measured when it is heated by an acetylene torch?

F-8

Camshaft, Timing Gear, and Chain Service

Objectives: *After completing this assignment, you will be able to—*

1. explain the conditions of the camshaft that indicate that repair must be made;
2. explain how the timing of the crankshaft and camshaft is done correctly;
3. explain why new sprockets should be installed when a new timing chain is installed; and
4. explain why the bore of the camshaft is slightly chamfered.

Reference: *Auto Service and Repair,* pp. 243-257.

Exercise:

1. Which tool is used to remove the vibration damper?
2. List four things the timing gears should be checked for.
3. What kinds of damage will insufficient backlash cause?
4. Why should the crankshaft gear be replaced when the camshaft gear is replaced?
5. What are two ways camshaft gears are attached to the shaft?
6. Which parts must be removed from the engine before the camshaft can be removed?
7. What kind of equipment is used to remove the camshaft gear from the camshaft?
8. Which tools are used to install the camshaft gear to the camshaft?
9. How should the camshaft be positioned when installing the camshaft and gear?
10. How can you be certain that the valves are timed correctly with the crankshaft?
11. What is the procedure for removing a timing gear without removing the camshaft?
12. What must be done before driving the new camshaft gear into place?
13. How can you prevent the teeth of the two gears from binding while the camshaft gear is being installed?
14. What tool is used to check the timing chain and sprocket for wear?
15. What is used to control the slack in long timing chains?
16. How should the timing marks on the crankshaft and camshaft gears be positioned before removing the timing chain?
17. Why is it best to install new timing sprockets when installing new timing chains?
18. What are two methods of installing timing sprockets?

19. How do you remove the timing chain cover oil seal?
20. Why must a centering sleeve be used if dowel pins are not provided to align the timing gear cover?
21. Which conditions indicate that the oil nozzles may be stopped up?
22. Name three methods of properly aligning timing marks for timing chains.
23. Name three methods of checking camshaft journal to bearing clearance.
24. Explain the looks of a correctly shaped wear pattern on the lobe.
25. Why is the camshaft bore slightly chamfered?
26. Which tools are used to install camshaft bearings?
27. Why is the installing bar rotated one-eighth turn counterclockwise after the bearing is aligned with the bore?
28. Why is it important to start the bearing straight?
29. What is done to some inserts to prevent them from turning?
30. How are the two different types of camshaft rear bearing core plugs sealed?
31. What tool is used to check the cam lobe lift?

F-9

Servicing Engine Blocks and Cylinders

Objectives: *After completing this assignment, you will be able to–*
1. explain how to remove metal from a cylinder head;
2. explain why a cylinder wears in a taper and out-of-round;
3. explain how reboring is done; and
4. explain how to hone a reground cylinder.

Reference: *Auto Service and Repair,* pp. 261-269.

Exercise:

1. What tools are used to check a block for distortion?
2. Why should a minimum amount of metal be removed from the block?
3. What should all threaded holes be checked for?
4. Why is the heaviest wear to the cylinders in the upper portion?
5. Explain what causes taper in the cylinder.
6. What causes the cylinder to wear out-of-round?
7. Why should the ring ridge be removed before pulling the pistons?
8. What is the purpose of the guide foot roller on the cylinder ridge reamer pictured in figure 16-3?
9. What should be done to prevent the ridge reamer from catching and causing chatter marks?
10. What kinds of damage should the cylinder be checked for after the piston has been removed?
11. Cylinders are rebored in what size increments?
12. Which tool is used to measure for taper and out-of-round?
13. How much taper is permissible?
14. What problems are caused by the piston tipping back and forth because of too much taper?
15. What damage will piston slap cause?
16. What is the maximum out-of-roundness permitted?
17. Why is it generally considered necessary for the cylinder wall to be honed (deglazed) before installing new rings?
18. At what angles should the deglazing crosshatch lines intersect each other?
19. Why is a rigid hone used when a cylinder has almost reached maximum acceptable taper and out-of-roundness?
20. Why should the hone never be pulled out while spinning?
21. On what kind of block is it especially important to remove the minimum amount of metal?
22. Why should alternate cylinders be bored?
23. What should you *not* use to clean a cylinder after honing?
24. What *should* be used to clean cylinders after honing?

F-10

Piston Service

Objectives: *After completing this assignment, you will be able to—*
1. explain how to clean a piston after removing it from the block;
2. explain the damages that may occur to ring grooves;
3. explain how to fit pistons to cylinders; and
4. explain how to fit piston pins to pistons.

Reference: *Auto Service and Repair,* pp. 269-280.

Exercise:

1. What conditions must a piston meet in order to be usable?
2. What is used to clean the carbon from a piston?
3. What kind of damage should the ring grooves be checked for?
4. How is a ring groove reconditioned?
5. In which parts of the piston will cracks cause it to be rejected?
6. What conditions indicate that a piston should be rejected?
7. How does knurling expand the circumference of the piston skirt?
8. How are new pistons and cylinders fitted to each other?
9. What tools are used to check the clearance between a cylinder and a piston?
10. What kind of movement between the piston and piston pin or piston pin and connecting rod is cause for rejection?
11. Why is it important to mark each rod and piston before they are disassembled?
12. Why must the clearance between the piston and the pin be more than enough for the pin to slide freely through the piston?
13. List five factors that affect pin clearances.
14. How should pins be fitted to pistons?
15. In which instances are bushings used as a bearing for the pin?
16. Why should a bushing be burnished after it has been installed?
17. Why is it important to provide the specified fit on the free end of a pin when one end is locked with a screw to one boss?
18. Why is it important that the pin be correctly centered when it is press fit to the connecting rod?
19. What is the danger of loose pin locks?

F-11

Ring Service

Objectives: *After completing this assignment, you will be able to—*

1. *name the two types of rings;*
2. *explain terminology of different types of rings;*
3. *explain how to install rings; and*
4. *explain how to space the rings around the piston.*

Reference: *Auto Service and Repair,* pp. 280-283.

Exercise:

1. What are the two basic types of rings?
2. Why are most rings now chrome-plated?
3. What are the three types of compression rings?
4. What terms are used generally to distinguish between rings for a rebored cylinder and rings for a worn cylinder?
5. Why is a gap or clearance at the ends of rings provided?
6. Where should the compression ring be gripped when removing it from the cylinder after checking the ring gap?
7. Why is it important that the groove in the piston not be too deep?
8. Which type of ring should have no side clearance?
9. How are multiple-piece oil rings forced into the groove?
10. What is used to install compression rings?
11. What can be used to protect the piston from the sharp rail end on the ends of rings that are spiraled into position in the grooves?
12. How should the ring gaps be spaced around the piston?

F-12

Rod Service

Objectives: *After completing this assignment, you will be able to—*
1. explain the importance of marking the rods and rod caps;
2. explain what causes the rods to become defective;
3. explain how to correctly resize rod bores; and
4. explain how to check the fit of rods after they have been installed.

Reference: *Auto Service and Repair,* pp. 283-290.

Exercise:

1. What should you check before removing any rods?
2. Why is marking the rods and caps so important?
3. What is the purpose of using rod bolt protectors?
4. Why must the ring ridge be removed before removing the piston?
5. What kinds of problems does the lightness of the rods tend to cause?
6. Describe a *twist* in a rod.
7. Describe a *bend* in a rod.
8. What are two methods of removing bend or twist?
9. What causes a rod to be offset when trying to straighten a bent rod?
10. What is the purpose of the regular offset built into a rod?
11. What should the connecting rod big end bearing bore be checked for?
12. Where does elongation occur in a rod big end bore as a general rule?
13. What finish should be produced on the rod big end bore with a honing machine?
14. What are the four basic steps in reconditioning the rod big end bore?
15. What should be used to clean the rod after it has been sized?
16. What should the final inspection of the rod include?
17. What should the rod and piston be lubricated with for installation?
18. What should be done to be sure the rings are fully compressed by the ring compressor?
19. In what position should the crankshaft be when the rod and piston are installed?
20. What should be done if the piston does not enter the cylinder with light tapping by a hammer handle?

21. How is the rod centered on the journal?
22. To check the insert clearance when the journal is out-of-round, why should you rotate the crankshaft just far enough to reach the cap?
23. Why is it important that the upper rod bearing be held against the top of the journal when torquing with the Plastigage in place?
24. What tool is used to check the connecting rod side play or clearance?

Section

G

Engine Lubrication and Ventilation Systems

G-1: Engine Lubrication System Service
G-2: Ventilation System Service

G-1

Engine Lubrication System Service

Objectives: *After completing this assignment, you will be able to—*

1. explain how to prevent engine timing from being thrown off when removing the oil pump;
2. explain the conditions that an oil pump should be checked for before reinstalling or replacing it;
3. explain how to repair pressure relief valves; and
4. explain the ratings of engine oil.

Reference: *Auto Service and Repair,* pp. 295-305.

Exercise:

1. Name the basic parts of the lubrication system.
2. What are the two types of oil pickups?
3. What happens on most cars when the oil pickup screen becomes clogged?
4. How may clogged oil screens be cleaned?
5. What is the purpose of the baffle in the pickup screen?
6. Why is it desirable to turn the engine until the number one piston is near the top of the firing stroke when removing the oil pump from many engines?
7. How should the distributor be marked so that it also can be set to fire on cylinder number one when it is replaced?
8. What is the purpose of marking the rotors or gears before pulling them?
9. How is end clearance of the inner and outer rotors checked?
10. How can you tell whether the wear is in the pump body or in the rotors?
11. What conditions should the rotors and shaft be checked for?
12. What tool is used to check the lash between the gears of a gear pump?
13. What should the body of any pump be checked for?
14. What should be done before starting an engine after an overhaul?
15. What is the purpose of the pressure relief valve?
16. What should be done if the pressure relief valve spring does not meet specifications?
17. How are oil distribution passages cleaned?
18. What are the three types of oil filtration systems?
19. How does the bypass relief valve of a full-flow system work?
20. Name the three types of filter elements.
21. What problems will overtightening a spin-on filter cause?
22. How is the filter checked for leaks?
23. At what temperature should the engine be when changing the oil?
24. What does SE-rated oil provide maximum protection against?

G-2

Ventilating Systems Service

Objectives: *After completing this assignment, you will be able to—*

1. *explain how the three ventilation systems work;*
2. *explain the function of the PCV valve;*
3. *explain how the PCV valve works; and*
4. *explain the symptoms of a defective PCV system.*

Reference: *Auto Service and Repair,* pp. 305-309.

Exercise:

1. Why is it important that the crankcase fumes be drawn off by the ventilation system?
2. How did the road draft crankcase ventilation system work?
3. What was the drawback to the open PCV system?
4. Why is a PCV control valve needed?
5. What force moves the PCV valve plunger forward to shut off much of the blow-by from the crankcase during idle?
6. What holds the PCV valve plunger backward to shut off all flow between the crankcase and the carburetor when the engine is off or during backfire?
7. Why is it important that fumes be prevented from "percolating" into the intake manifold when the engine is off?
8. Trace the flow of fumes and blow-by during high speed or heavy acceleration.
9. How can you tell whether or not there is a vacuum in the system if a PCV system gauge is not available?
10. What symptoms indicate that the valve is tightly plugged or stuck in a closed position?
11. What symptoms indicate that the valve is stuck in a partially closed or idle position?
12. What symptoms indicate that the valve is stuck in the normal operating position?
13. What indicates that a PCV valve can or cannot be disassembled and cleaned?
14. What will result if a closed system cap is installed on an open PCV system?
15. What will result if the PCV system is inoperative?

Section

H

Cooling Systems

H-1: Cooling System Service

H-1

Cooling System Service

Objectives: *After completing this assignment, you will be able to–*

1. *name the three types of antifreeze;*
2. *explain how to backflush a radiator;*
3. *explain the purpose of pressurizing a cooling system;*
4. *explain how to recognize faulty water hoses;*
5. *explain how to install thermostats; and*
6. *explain how to service water pumps.*

Reference: *Auto Service and Repair,* pp. 319-336.

Exercise:

1. Where does the energy developed in the engine go?
2. Why should soft water be used in the cooling system?
3. What are the advantages of ethylene glycol over denatured alcohol and methanol?
4. What two functions does ethylene glycol perform?
5. How long is the coolant in a new vehicle effective?
6. What condition indicates that the system should be drained and cleaned?
7. How is the coolant level of a closed system checked?
8. What instruments are used to test the amount of antifreeze in the coolant?
9. How are mild rust and scale conditions corrected?
10. Why should the heater be set at maximum heat when cleaning the radiator with a chemical preparation?
11. Why is it important to use a neutralizer when an acid cleaner is used?
12. Why is reverse flushing used?
13. Why should no more than 20 lb of air pressure be used?
14. Why must the water pump be removed on some automobiles before reverse flushing the block?
15. Why will cleaning sometimes cause leaks?
16. How can the cooling system be checked for internal leaks with a pressure gauge?
17. How can it be determined which bank of an eight-cylinder engine is leaking?

18. How can the cooling system be checked for internal leaks with chemicals?
19. What other areas can be checked to determine whether or not an internal leak exists?
20. How do pressure caps on the radiator affect the temperature at which the coolant boils?
21. What precautions should be used when replacing radiator caps?
22. What precaution should be used when removing a radiator cap from a hot radiator?
23. What should be done if the engine is greatly overheated and steam is flowing from the overflow?
24. How should water be added to a hot engine?
25. What signs of deterioration can be checked for by squeezing the hose?
26. Why is a soft hose on the bottom of particular importance?
27. Why should a rigid hose not be used between the radiator and the engine?
28. Why should a thin coat of nonhardening gasket cement be put on the metal hose fitting but not on the hose itself?
29. What conditions should the drive belt be inspected for?
30. What steps should be taken before removing the belt?
31. What will result from a belt being too loose?
32. What will result from a belt being too tight?
33. Under what conditions should the fan be replaced?
34. How is a defective fluid drive fan clutch corrected?
35. What problems can result from a stuck thermostat that overheats the engine?
36. What problems can result from a stuck thermostat that overcools the engine?
37. What will happen if a thermostat is installed in reverse?
38. What are the most common water pump problems?
39. What should be done before dismantling a water pump?
40. How is the pulley removed from the shaft?
41. Where on the bearing is pressure exerted when pressing a new bearing in place?
42. What are two ways to remove core hole plugs?

Section

I

Fuel Systems

I-1: Fuel Tanks, Fuel Lines, and Fuel Pumps
I-2: Carburetor Adjustments
I-3: Choke and Anti-stall Dashpot Adjustments
I-4: Accelerator Pump, Fioat, and Other Carburetor Adjustments
I-5: Fuel Injection
I-6: Diesel Fuel Injection

I-1

Fuel Tanks, Fuel Lines, and Fuel Pumps

Objectives: *After completing this assignment, you will be able to—*

1. explain how to store gasoline;
2. explain how to test a fuel pump;
3. name and explain how the four electric fuel pumps operate;
4. explain how to repair a damaged gasoline tank; and
5. explain how to correctly install a fuel pump.

Reference: *Auto Service and Repair,* pp. 339-353.

Exercise:

1. What should *not* be done to start siphoning action when removing fuel from a tank?
2. What kind of containers should gasoline be stored in?
3. Why should the battery ground strap be removed before disconnecting and removing the fuel tank?
4. How should a tank be prepared before soldering or brazing?
5. Why is it dangerous to use carbon tetrachloride when brazing a fuel tank?
6. Why should water be used rather than air to remove dents in a fuel tank?
7. What is used to clean out a fuel line?
8. What should happen to fuel pump pressure after the engine is stopped?
9. How much fuel should a pump deliver in one minute?
10. What is the first thing that should be checked when a pressure or volume test does not meet specifications?
11. What is the minimum reading that a vacuum test should produce?
12. How can you tell whether the flex hose or the pump is causing the vacuum to drop rapidly when the engine is stopped?
13. How can a defective vacuum booster fuel pump cause the engine to use oil?
14. Name the four types of electric fuel pumps.
15. What are the two types of pump repair kits?

16. What should be done with the pulsator diaphragm after the pump is disassembled?
17. Which parts from the fuel pump should be discarded?
18. What are two ways of securing diaphragm pull rod oil seals?
19. What is the purpose of using an undersize pin when assembling the diaphragm and rocker arm?
20. How is the rocker arm pin held inside a retaining washer?
21. What is the correct position for an oil seal installed on the diaphragm pull rod?
22. What is the correct position for the opening in a pulsator diaphragm?
23. What will result if the pump is installed with the rubbing pad not against the eccentric or pushrod?
24. Which types of fuel filters can be cleaned and blown dry?
25. What causes vapor lock?
26. What is a temporary cure for vapor lock?

I-2

Carburetor Adjustments

Objectives: *After completing this assignment, you will be able to–*

1. *explain which systems should be checked before working on a carburetor;*
2. *explain how to set the idle adjustment screw;*
3. *explain how to set idle cam linkage;*
4. *explain how to set the idle mixture adjustment; and*
5. *name the instruments used to adjust the carburetor.*

Reference: *Auto Service and Repair,* pp. 353-357.

Exercise:

1. Which systems should be checked before working on a carburetor?
2. What is the first step in making the fast-idle speed adjustment?
3. What should be done if the idle adjustment must be made with the transmission engaged and the vehicle is equipped with a vacuum emergency brake release?
4. Why should the emergency brake release vacuum line be disconnected at the diaphragm?
5. How is the engine brought to the specified engine rpm?
6. Why is the relationship between the fast-idle cam position and the choke valve opening important?
7. Some carburetors require that the choke be open a measured distance. How can the correct adjustment be determined?
8. How is fast-idle cam linkage adjusted?
9. Which components of the vehicle may or may not be engaged when setting the slow-idle speed?
10. How is a hot-idle compensator valve held closed to prevent damage to it?
11. Which way is an idle-air adjusting screw turned to increase engine speed?
12. Why must idle mixture screw adjustments be made when hot-idle speed adjustment is made, particularly on idle-air adjustments?
13. Where is a single screw adjustment made for both slow and fast idle?
14. When should the idle mixture be adjusted?
15. What do the emission control limiter caps do?

16. Which two instruments are used to adjust a single-barrel carburetor?
17. Between which two positions is the idle mixture screw set for the initial adjustment of a single-barrel carburetor?
18. How is the final adjustment on the single-barrel carburetor determined?
19. How close to the same number of turns should each of the adjusting screws be set?
20. What may be the problem if turning the idle mixture screw does not affect the engine's performance?
21. What may be the problem if the mixture screw must be screwed almost completely in to produce a smooth idle?
22. Which other systems should you check that may affect the engine idle?

I-3

Choke and Anti-stall Dashpot Adjustments

Objectives: *After completing this assignment, you will be able to--*

1. *explain what determines the position of the choke valve;*
2. *explain how to clean an automatic choke;*
3. *explain how to recognize when a choke needs to be set richer or leaner;*
4. *explain how to set the throttle choke valve break; and*
5. *explain how to adjust an anti-stall dashpot.*

Reference: *Auto Service and Repair,* pp. 358-363.

Exercise:

1. What is the purpose of leaving the choke knob ⅛ inch out before tightening the swivel block?
2. How can you be certain that you can replace an automatic choke to the same setting it had before it was removed?
3. How is the automatic choke cleaned?
4. What is used to clean the choke shaft bearings and external linkage?
5. Where is the remote thermostatic spring located?
6. What is the purpose of the vacuum diaphragm choke "break"?
7. What determines the thermostatic spring tension?
8. What conditions indicate the need for a richer setting?
9. What conditions indicate the need for a leaner setting?
10. What determines the choke valve position during warm-up?
11. What is the purpose of exerting a light pressure on the choke valve in the closing direction while measuring the distance between the choke valve and the air horn?
12. How is the vacuum diaphragm adjusted?
13. How is the throttle choke valve break adjustment made?
14. In what position should the throttle be when adjusting the anti-stall dashpot?
15. What are the characteristics of a properly operating dashpot?

I-4

Accelerator Pump, Float, and Other Carburetor Adjustments

Objectives: *After completing this assignment, you will be able to—*

1. *explain how to recognize problems associated with floats set too high and too low;*
2. *explain how to set the float level;*
3. *explain how to disassemble and clean a carburetor; and*
4. *explain how to reassemble a carburetor.*

Reference: *Auto Service and Repair,* pp. 363-368.

Exercise:

1. Describe the stream of fuel that is discharged into the air horn when the throttle is opened from idle to full throttle quickly.
2. What can cause the carburetor pump to deliver less than the required amount of fuel when the pump is activated?
3. What conditions will result from the fuel level in the fuel bowl being too high?
4. What conditions will result from the fuel level in the fuel bowl being too low?
5. How is the fuel level checked?
6. How is the float adjustment made?
7. How is a float drop setting checked?
8. How is the float drop setting adjusted?
9. What is a second method of adjusting a float level?
10. What conditions must be met before checking the exact fuel level?
11. Which direction raises the fuel level where an adjustable needle seat is used?
12. What are two methods of checking to see if the float leaks?
13. Why should repair legs be used when working on carburetors?
14. What should you do before disassembling a carburetor so that you can put the parts back in the position they came from?
15. How should all metal parts of the carburetor be cleaned?

16. What condition indicates that the float needle and valve need to be replaced?
17. What precaution should be taken when assembling a carburetor?
18. Why must the throttle linkage adjustment on some cars with automatic transmissions be exact?
19. What should all rod and cable linkage be checked for after assembly?
20. Why should you avoid oiling the carburetor throttle shaft, automatic choke, choke shaft, etc?
21. What usually causes the heat riser to stick?
22. What is used to free a stuck heat riser?

I-5

Fuel Injection

Objectives: *After completing this assignment, you will be able to—*

1. *explain the advantages of fuel injection;*
2. *explain how the fuel is injected into the intake system;*
3. *explain the checks that can be made on fuel injectors;*
4. *name the types of fuel injector systems;*
5. *explain how a fuel injector system works; and*
6. *give the safety precautions to exercise when working on a fuel injection system.*

Reference: *Auto Service and Repair,* pp. 368-382.

Exercise:

1. What are the advantages of using fuel injection rather than a carburetor?
2. Where does fuel injection take place on a gasoline engine?
3. Where is the fuel atomized in the mechanical fuel injection system?
4. How much pressure does a mechanical fuel injection system develop before injection?
5. How is the pressure of fuel in the system relieved before being disassembled?
6. Why is it so important to have clean fuel in the injector system?
7. What is the purpose of each of the two idle adjusting screws on some systems?
8. What equipment is used to provide part load and full load required to set fuel mix adjustments?
9. Under what conditions should an injector pump overhaul be done?
10. What can injectors be tested for?
11. How do the pressure requirements of an electric fuel injection pump compare with those of a mechanical pump?
12. At what time is fuel injected when a fully timed intermittent system is used?
13. How does the injection timing work in a system that uses the group method of injection?
14. What does the air induction system of an intermittent injection system include?
15. What is the purpose of the in-tank fuel pump?
16. How much pressure does the second fuel pump maintain?
17. What happens to the excess fuel delivered by the fuel pumps?

18. What is the "rail" in an injector system?
19. What permits fuel to be injected into the intake manifold?
20. How long does a spray interval, or "pulse width," last on the injector shown in figure 20-74?
21. What kinds of information are fed to the electronic control unit by the sensors?
22. What does the electronic control unit do with the information fed to it?
23. What does the manifold pressure tell the computer?
24. What do the two temperature sensors monitor?
25. What is the function of the cold start valve?
26. At what temperature does the cold start cease to be activated?
27. What is the function of the thermal time switch?
28. What is the function of the auxiliary air regulator?
29. How do continuous fuel injectors differ from intermittent fuel injectors?
30. What determines the amount of fuel allowed to flow to the injectors?
31. What actuates the fuel distributor?
32. Why is it important that a constant pressure drop exist through the fuel distributor metering slots?
33. In the pressure regulating valve, what provides the difference between the 64 psi in the lower half and the 62.5 psi in the upper half?
34. What is the purpose of the pressure control chamber above the control plunger?
35. What should be done before loosening any fuel injection fuel lines?
36. What should be done before diagnosing the system when experiencing system problems?
37. What four steps should be followed in the initial visual inspection?

I-6

Diesel Fuel Injection

Objectives: *After completing this assignment, you will be able to—*
1. explain how diesel fuel injection is accomplished;
2. explain how ignition takes place;
3. explain the function of turbochargers; and
4. explain how to service air filters.

Reference: *Auto Service and Repair,* pp. 382-390.

Exercise:

1. Name three ways in which diesel fuel injection differs from gasoline injection.
2. What may the diesel injector be checked for?
3. Why must the nozzle be cleaned very carefully with the proper tools?
4. Why should you *never* direct the nozzle towards your body when conducting tests?
5. Why are glow plugs used?
6. How long may current flow through the connecting resistor wires after the control light goes out?
7. What kinds of problems can dirty injectors cause?
8. What powers turbosuperchargers?
9. What is the function of turbochargers?
10. Why should you use extreme care when handling or repairing a turbocharger?
11. How may paper filters be cleaned?
12. How should excess liquid be removed from a polyurethane element after it has been cleaned?
13. Why is it important to remove the entire filter rather than removing the top and lifting out the element?
14. How do you clean the strainer unit of the oil bath air cleaner?
15. How is the strainer treated to make it collect dust more efficiently?

Section

J

Ignition System Service

J-1: Checking the Ignition Circuit, Coil, and Distributor Cap
J-2: Testing and Adjusting the Distributor
J-3: Installing the Distributor and Checking Spark Plugs
J-4: Checking the Ignition System with an Oscilloscope

J-1

Checking the Ignition Circuit, Coil, and Distributor Cap

Objectives: *After completing this assignment, you will be able to—*
1. explain the defective conditions found in the ignition system;
2. explain how to test the ignition system;
3. explain why the polarity of the spark plug is important; and
4. explain how to prevent cross wiring.

Reference: *Auto Service and Repair,* pp. 395-405.

Exercise:

1. What should the primary circuit winding be checked for?
2. When making a battery-to-coil voltmeter check, what should be checked if the reading is above 6.9 volts?
3. What could a reading of 4.5 volts or less indicate?
4. What is the maximum voltage drop permissible when running the ignition circuit test?
5. What should be checked if excessive voltage drop is present during the coil-to-ground test?
6. To which points should the voltmeter be hooked when testing the ignition switch?
7. What voltmeter reading indicates that the switch is all right?
8. What is the maximum reading permitted when checking the resistance of the ignition wire?
9. How can the available voltage from the ignition coil be determined when using the oscilloscope?
10. What can cause flashover in the tower of the coil?
11. What kinds of conditions does flashover cause that render the coil useless?
12. When the coil polarity is connected correctly, what is the polarity of the center electrode of the spark plug?
13. Why is it important that the spark plug fire from the center electrode?
14. In which direction will the needle on the voltmeter flicker if the coil polarity is wired correctly?
15. On which side of the lead does the flare or glow appear when the pencil test is used and the polarity is connected correctly?
16. What is the procedure for removing and replacing secondary wiring to prevent cross wiring?
17. Why should the resistance wires be removed from the plug by the boot rather than the wire itself?
18. How is crossfiring of adjacent cylinders on the same bank prevented?
19. Where is cylinder number one located on a six-cylinder engine?
20. How can the number one cylinder be found if the manufacturer's shop manual is not available?
21. What conditions should the distributor cap wire towers be checked for?
22. What conditions of the terminal posts indicate that the cap needs to be replaced?

J-2

Testing and Adjusting the Distributor

Objectives: *After completing this assignment, you will be able to—*
1. explain how to repair slightly worn points;
2. explain "dwell" in timing an engine;
3. explain the characteristic of a normal spark advance as engine rpm is increased; and
4. name the forces that cause the spark to advance.

Reference: *Auto Service and Repair,* pp. 405-413.

Exercise:

1. What conditions should the rotor be checked for?
2. Name two ways of removing rotors.
3. What conditions indicate that the points should be replaced?
4. Which tools are used to clean up the breaker points?
5. What causes rapid rubbing block wear?
6. Where is the recommended site for point replacement?
7. What should be done to ensure that the distributor is reinstalled in the correct position?
8. How does too wide a gap affect the way the engine runs?
9. Why are new gap specifications larger than those for used points?
10. What is the result of too much tension on the breaker arm?
11. What will result from too little tension on the breaker arm?
12. How is the breaker arm tension increased when the breaker arm spring is slotted?
13. How is tension increased on springs that have no slot?
14. When is the ignition condenser normally changed?
15. What kind of lubricant should be used on the distributor cam?
16. What is the *dwell?*
17. What controls the dwell of any given cam?
18. What instrument is used to set the dwell?
19. What should be the characteristic of the spark advance when an engine's rpm is increased from idle to 4,000 rpm with the vacuum line disconnected?
20. What should happen to the timing mark when a disconnected vacuum advance line is connected to an engine that is running at approximately 1,200 rpm?
21. What is used to adjust centrifugal advance spring tension?
22. How is spring tension adjusted on adjustable vacuum advance units?
23. What should be done before removing the gear from the distributor shaft?

J-3

Installing the Distributor and Checking Spark Plugs

Objectives: *After completing this assignment, you will be able to--*

1. *explain the procedure for timing an engine;*
2. *explain what carbon buildup does to an engine;*
3. *identify the condition of the engine by noting the color of the spark plugs; and*
4. *explain how to correctly install spark plugs.*

Reference: *Auto Service and Repair,* pp. 413-423.

Exercise:

1. What should be done to compensate for the rotation of the shaft after the gears engage when installing a distributor?
2. What should be done if the distributor will not bottom?
3. Why should the timing be slightly retarded during initial distributor timing?
4. What should be done to make the specified timing on the damper easier to see while timing?
5. Why should the engine be at slow idle while timing?
6. Why should modern engines not be "road timed"?
7. What factors can affect the spark plug service life?
8. What kind of socket should be used to remove and replace the spark plugs?
9. How is foreign matter removed from around the spark plugs?
10. What is the normal color of deposits on a spark plug that is operating in a sound engine at the correct temperature?
11. How does oil fouling affect the spark plug?
12. What does fuel fouling do to the spark plug?
13. What should be done if there is evidence of aluminum throw-off?
14. What should be done to correct high-speed glazing?
15. What causes overheating?
16. What causes preignition?
17. What causes turbulence burning?
18. Why should all cylinders be checked if mechanical damage is found on one spark plug?
19. What should be done if the abrasive in a spark plug cleaning machine tends to pack in the plug?
20. Why is it necessary to file both electrodes even though the plug has been cleaned in a machine?
21. Why is it important to use a torque wrench when tightening spark plugs?
22. What controls the heat range of a spark plug?
23. What can result from installing a spark plug with excessive reach?

J-4

Checking the Ignition System with an Oscilloscope

Objectives: *After completing this assignment, you will be able to–*

1. *explain the purpose of the oscilloscope;*
2. *explain the meaning of the different patterns on the waveform;*
3. *explain how malfunctions can be seen on the waveform;*
4. *name the three types of electronic ignition systems; and*
5. *explain how emission control systems affect timing.*

Reference: *Auto Service and Repair,* pp. 423-429.

Exercise:

1. What is the purpose of using an oscilloscope?
2. What does the firing line of the waveform indicate?
3. What happens to the voltage during the time the spark plug is firing?
4. What causes the wavy line between the time the spark stops jumping the gap and the time the points close?
5. What happens to the wave pattern when the points close?
6. Why is it important to understand the patterns of the oscilloscope?
7. What happens to the pattern when the coil polarity is reversed?
8. What kind of pattern is caused by worn distributor caps?
9. What are three basic types of electronic ignition systems?
10. What is the most commonly used electronic ignition system?
11. What induces voltage in the coil in a magnetically controlled system?
12. Name two advantages of the breakerless ignition system over the breaker ignition system.
13. Up to how many volts does a capacitor discharge system charge a capacitor in the primary circuit?
14. How does the high voltage in the primary circuit affect the voltage in the secondary circuit of a capacitor discharge system?
15. What differences can be seen on the oscilloscope between the electronic ignition system and the point and condenser ignition system?
16. Why should an engine not be run longer than necessary with a plug shorted out?
17. How do some emission controls affect engine timing?
18. Where does the Chrysler Spark Control Computer receive its information from in order to set the spark advance or retard?

Section

K

Electrical System Service

K-1: Checking and Servicing the Battery
K-2: Checking and Servicing DC Generators
K-3: Checking and Servicing AC Generators
K-4: Checking and Servicing Regulators
K-5: Starter System Service

K-1

Checking and Servicing the Battery

Objectives: *After completing this assignment, you will be able to–*

1. *explain why safety precautions must be taken when servicing a battery;*
2. *explain how to remove corrosion from battery terminals and posts;*
3. *explain how the specific gravity of electrolyte is affected by the amount of charge;*
4. *explain how to conduct the open circuit test, capacity test, and three-minute test;*
5. *explain how to give slow and fast charges; and*
6. *explain why maintaining the correct polarity is important.*

Reference: *Auto Service and Repair,* pp. 431-440.

Exercise:

1. Which acid is used in the electrolyte?
2. What should be done if electrolyte gets in the eyes?
3. Why should open flames around a battery be avoided?
4. What conditions should be looked for when giving a battery a visual check?
5. What is used to clean corrosion from terminals, posts, and the battery top?
6. What will result from tightening the hold-down device too tight?
7. What kind of water should be added to a battery?
8. What determines the efficiency of a given battery?
9. What causes the weight of electrolyte in a discharged battery to be lighter than that in a charged battery?
10. What is the *surface charge?*
11. Why should electrolyte be drawn in and squirted out several times before taking a reading?
12. How is the specific gravity of the electrolyte related to how high the float will ride out of the electrolyte?
13. How much would be subtracted from the specific gravity reading if the temperature reading of the electrolyte is 60°F?
14. What does cold weather do to the efficiency of a battery?
15. When should a battery be charged?

16. What kind of reading on an open circuit (no load) voltage test indicates that the battery should be given a capacity test to determine its suitability for further service?
17. What should be done before testing for capacity when the specific gravity is below 1.220?
18. What load should be placed on the carbon pile to make a capacity (load) test?
19. How long should this load be kept on the battery?
20. What voltmeter reading indicates ample capacity for a 12-volt battery?
21. Under what two conditions should a battery be replaced after conducting the three-minute test?
22. Under what conditions is the battery considered sound after conducting the light-load battery test?
23. How much time does a slow charge usually involve?
24. What is the purpose of a slow charge?
25. What is the maximum temperature the battery should be allowed to reach while charging?
26. For a fast charge on a 12-volt battery, how much current and how much time are involved?
27. Why should a slow charge be used to complete a fast charge?
28. How does the hookup of more than one battery on a fast charge differ from the hookup of more than one battery on a slow charge?
29. How long may a dry-charged battery be kept without activating it?
30. Why should the electrolyte be added until the separators are just covered when activating a dry-charged battery?
31. What can be safely added to a battery?
32. Which terminal is grounded on domestic cars?
33. What should you never do when trying to remove a terminal from a battery post?
34. Why is it important that the correct polarity be maintained when batteries are exchanged?
35. How can the positive and negative posts be identified?
36. Which colors signify positive and negative on domestic vehicles?
37. How is a voltmeter connected to determine whether or not there is a battery drain?

K-2

Checking and Servicing DC Generators

Objectives: *After completing this assignment, you will be able to–*
1. relate symptoms to their probable causes for electrical problems;
2. explain how to test A and B circuit generators;
3. explain how the commutator is turned and cleaned; and
4. explain how to polarize an overhauled generator.

Reference: *Auto Service and Repair,* pp. 441-452.

Exercise:

1. What are indications that the battery is constantly being overcharged?
2. What are indications that the battery is being undercharged?
3. What indicates system problems?
4. Under what conditions should the charge indicator not light when the ignition switch is on?
5. Why does an open diode on an AC generator cause the generator to be noisy?
6. What conditions can cause generators to click, squeal, and growl?
7. Why should the battery be checked before assuming some part of the charging system is at fault?
8. Why is it important to locate the cause of a failure rather than just replace the part that failed?
9. How will a wire with excessive resistance affect the ability of the generator to charge the battery?
10. What is the difference between the results of connecting a voltmeter between the generator field terminal and the ground of an A circuit and a B circuit?
11. What happens if a jumper wire is installed between the regulator field terminal and the ground of a Delco-Remy single- and double-contact voltage regulator?
12. What is the maximum voltage reading on a voltmeter when testing the resistance of a double-contact voltage regulator?
13. Where is the ammeter attached to the generator when checking an A circuit generator for output?
14. How many amperes should a generator produce?
15. What is the problem if there is no amperage indicated but the voltage is higher than the normal battery voltage?
16. What may be the problem if there is no amperage reading with a voltmeter reading below that of normal battery voltage?

17. At what rpm should the output test be made?
18. Which parts of the generator are cleaned with a solvent?
19. What conditions should all parts be examined for?
20. How are field coils checked for grounds?
21. How are field coils tested for open circuit?
22. How is an armature tested for ground?
23. What tool is used to test an armature for shorts and what indicates that the armature has a short?
24. What should be done to test for shorts in an armature that appears to have been overheated?
25. Which part of the commutator is turned in a lathe?
26. What should not be used to clean the turned area?
27. Why must the mica separating the bars of the commutator be undercut after turning the armature?
28. What conditions should the drive end bearing be checked for?
29. What kind of grease should drive end bearings be packed with?
30. Why should a bearing not be packed full of grease?
31. Why are new brushes always installed when generators are overhauled?
32. What can be done to hold the brushes in an out position while installing the end plate?
33. What causes brush springs to lose their tension?
34. How can you be certain that the end plates and frame unit are aligned?
35. What is the purpose of motoring a generator after overhauling it?
36. Why is it important to polarize a DC generator before starting the engine?
37. How is an A circuit generator polarized?
38. How is a B circuit generator polarized?
39. What kind of oil is used to lubricate a generator with oiler cups or holes?

K-3

Checking and Servicing AC Generators

Objectives: *After completing this assignment, you will be able to–*

1. explain the safety precautions to exercise when repairing an alternator;
2. explain how to test diodes;
3. explain how to test the circuits of the alternator;
4. explain how to clean the parts of the alternator; and
5. tell why an alternator does not require polarization.

Reference: *Auto Service and Repair,* pp. 452-459.

Exercise:

1. Why is it important to hold a diode lead with a pair of pliers when soldering it?
2. Why should an alternator never be operated on open circuit?
3. Why is it important to remove the battery ground lead before removing or replacing system wires or units?
4. How is a bad connection located and corrected?
5. How many amperes should the alternator be producing when the alternator to battery positive terminal resistance test is conducted?
6. How much will a shorted diode reduce output and how much will an open diode reduce output, when checking the alternator output?
7. What three practices can ruin the diodes in a generator?
8. What instruments are used to test diodes?
9. When making a diode check with a test lamp, what results will be seen for a good diode, an open diode, and a shorted diode?
10. When making a diode check with an ohmmeter, what results will be seen for a good diode, an open diode, and a shorted diode?
11. Which part of the diode may have pressure brought against it without damaging the diode?
12. What should be done to ensure that the alternator is replaced in the same position it was before it was disassembled?
13. Which parts should not be cleaned with solvent?
14. What should the brushes be cleaned with?

15. What is the procedure for testing a rotor for grounds with an ohmmeter?
16. How are slip rings cleaned?
17. How are out-of-round slip rings corrected?
18. Explain three ways of keeping the brushes out of the way during assembly.
19. How is an alternator polarized?

K-4

Checking and Servicing Regulators

Objectives: *After completing this assignment, you will be able to—*

1. *explain why a cutout is not needed on an alternator;*
2. *explain how adjustments are normally made on points of regulators;*
3. *explain how to clean the regulator points;*
4. *explain how to test regulators for malfunctions; and*
5. *explain why a heat sink is required when soldering a diode lead.*

Reference: *Auto Service and Repair,* pp. 459-471.

Exercise:

1. What three things does a DC regulator control?
2. Why does an alternator regulator not have a current regulator?
3. Why does an alternator regulator not have a cutout?
4. Why are cutouts used in some models when they are not needed to prevent the current from flowing when the engine is dead?
5. What kinds of electronic parts do fully transistorized regulators use to regulate the output from the alternator?
6. How long should an engine be warmed up before testing the regulator?
7. Why is it important that you follow the manufacturer's instructions when testing regulators?
8. What is indicated if there is more than a 2-amp increase when the A and double-contact circuit tests are made for oxidized points?
9. What should be used to clean soft points?
10. What are hard points cleaned with?
11. Why should the file be held parallel to the centerline of the point armature?
12. Which two pieces of equipment or instruments are used to test for cutout relay closing voltage?
13. Where is the variable resistance connected to the electrical system when checking the cutout relay closing voltage?
14. How are adjustments made on the point gap of cutout relays?

15. What is the maximum amount of amperes the variable resistance should be set to cause the generator to produce when testing the DC generator regulator voltage limiter?
16. How is the generator cycled?
17. Why is it important to test the voltage limiter or regulator setting with the cover on and with it off?
18. What is the purpose of placing the ¼-ohm fixed resistor between the battery terminal and lead on the double-contact generator when checking voltage output?
19. What is the purpose of inserting the variable resistance into the circuit before the circuit will be opened?
20. How is the upper-contact voltage setting changed on a double-contact regulator?
21. How is the voltage spread decreased or increased?
22. How is the air gap on double-contact voltage regulators adjusted?
23. What is used to induce a load when testing the current regulator setting?
24. How is the generator cycled when checking the alternator voltage regulator setting?
25. What is indicated when the generator charges more than 10 amp during an alternator voltage regulator setting check?
26. At what rpm should the engine be set when checking the voltage setting when the regulator is operating on the shorting points?
27. How can you tell when the upper points stop operating and the lower points start operating?
28. What precaution should be taken when adjusting the alternator double-contact voltage regulator setting?
29. How is a field relay closing voltage check made?
30. What can be used to protect a diode when soldering or unsoldering?
31. What conditions should a transistor be checked for?
32. What should be done if repairing a regulator fails to correct the problem?

K-5

Starter System Service

Objectives: *After completing this assignment, you will be able to—*

1. explain how to properly crank a motor that does not start immediately;
2. explain what conditions each of the starter tests reveals;
3. explain why a starter motor should be scribed before disassembly;
4. explain how to turn a commutator; and
5. explain how to test the clearance of the overrun clutch.

Reference: *Auto Service and Repair,* pp. 472-480.

Exercise:

1. What conditions of the starting system should be visually checked?
2. What is the maximum permissible voltage drop when checking the battery voltage drop?
3. What is the maximum amount of time a starter should be operated before allowing it to cool?
4. Where should the exact voltage drop for any particular automobile be found?
5. Name four parts of the starting circuit that should be checked other than the battery, starter, and wiring.
6. What kind of information can the starting load test give you?
7. Which instruments are used to make the starter load test?
8. Why is it important to secure the starter before making the no-load test?
9. Why is it important to make the stall torque test as quickly as possible?
10. What kind of problems will the stall torque test reveal?
11. What should be done before disassembly to ensure the correct reassembly of a starter?
12. Which parts of the starter should not be cleaned in a solvent?
13. Why is the overrunning clutch drive never placed in solvent?
14. How does the growler test reveal a shorted section of the armature?
15. What should be done with grounded or shorted armatures?
16. What often happens to a starter that has overheated from prolonged starting?

17. How is an armature repaired if it has some solder melted and thrown from it?
18. How much copper should be removed from the commutator when turning it?
19. How deep should the mica insulation between the bars be cut?
20. What should be used to polish the commutator?
21. Where should the test light prods be placed to check field coils for opens?
22. Where should the test light prods be placed to check field coils for grounds?
23. Under what conditions should brushes be replaced?
24. What is used to lubricate the bushings?
25. What kind of solder should be used to repair generator circuits?
26. How is the overrunning clutch clearance checked?
27. What can be done to prevent the armature from rotating when the solenoid is energized to check the overrunning clutch clearance?
28. Why must the mounting flange or pad be cleaned spotlessly?

Section

L

Engine Tune-up

L-1: Engine Tune-up

L-1

Engine Tune-up

Objectives: *After completing this assignment, you will be able to—*

1. *explain the purpose of a tune-up;*
2. *distinguish between basic and complete tune-ups;*
3. *name the types of information that should be obtained from the owner concerning the problem; and*
4. *explain the purpose of giving the compression, vacuum, and balance tests.*

Reference: *Auto Service and Repair,* pp. 485-492.

Exercise:

1. What is the purpose of an engine tune-up?
2. Why is it important to spell out exactly what is meant by tune-up?
3. Why do many shops refuse to do basic tune-ups?
4. Why is it important to have quality equipment when making a tune-up?
5. What kind of information should you get from the vehicle owner about the engine's performance?
6. Why should accurate records be kept of all service jobs?
7. Why should a compression test be made before proceeding with a tune-up?
8. How many compression strokes are necessary to raise the gauge to its highest point?
9. What preparation must be made before taking the compression test?
10. How much compression variation is allowable between the cylinders?
11. What is indicated when the needle raises only a small amount on the first stroke and little more on succeeding strokes and ends up with a very low reading?
12. What is indicated when the needle has a low buildup on the first stroke, with a gradual buildup on succeeding strokes, to a moderate reading?
13. What is indicated if two adjacent cylinders are low?
14. What is indicated if a low-pressure reading improves after adding 30W engine oil and another test is taken?
15. What is indicated if there is no improvement in the low reading after adding the engine oil?

16. What is indicated if the compression pressure exceeds specifications and the engine has not been modified to increase compression?
17. What should be done if the pinging from carbon buildup cannot be stopped by using higher octane gasoline or by retarding the spark?
18. How can you determine if the intake or exhaust valve is leaking?
19. How can you determine that the rings are leaking?
20. Why must possible problems indicated by the vacuum gauge be checked by other instruments or tests?
21. What is indicated by a low, but fairly steady reading on the vacuum gauge?
22. What does an erratic reading of the vacuum gauge indicate?
23. How does the elevation above sea level affect the atmospheric pressure?
24. How does the modern design of high-lift cams and considerable valve overlap affect the vacuum reading?
25. What problems may be caused by vacuum leaks?
26. On which engines should you not use the cylinder balance test?
27. What results of the cylinder balance test indicate that an unbalanced condition exists?
28. What should be done before starting the tune-up?

Section

M

Power Train Service

M-1: Clutch Service
M-2: Manual Transmission Service
M-3: Overdrive and Four-Wheel Drive Service
M-4: Automatic Transmission Checks
M-5: In-Car Transmission Repair
M-6: Transmission Removal
M-7: Propeller Shaft and Universal Joint Service
M-8: Troubleshooting and Disassembling the Axle and Housing
M-9: Differential Disassembly and Repair

M-1

Clutch Service

Objectives: *After completing this assignment, you will be able to--*
1. explain why it is important to locate the cause of a part failure;
2. explain how to prepare the face of the flywheel and pressure plate;
3. explain how to correct clutch housing misalignment; and
4. explain how to make adjustments for correct clutch operation.

Reference: *Auto Service and Repair,* pp. 517-529.

Exercise:

1. What two methods are used to apply force to the pressure plate?
2. What should be done before repairing a damaged clutch?
3. What should be checked before condemning the clutch?
4. Why should the clutch cover and flywheel be marked so that they can be reassembled the way they were?
5. Why should each clutch cover to flywheel fastener be loosened one turn at a time?
6. What kind of cleaner is used to clean the flywheel face and pressure plate assembly?
7. Why should the throwout bearing not be cleaned with a solvent?
8. What is the purpose of lightly sanding the flywheel and pressure plate?
9. What should the pressure plate assembly be checked for?
10. What should the coil springs or diaphragm spring be checked for?
11. Generally, who should rebuild pressure plates?
12. Why is it important that the pressure plate be withdrawn an equal amount around the entire circumference?
13. How are the release fingers adjusted to the correct specifications?
14. How are the adjusting nuts held in place during service?
15. What problems do worn pilot bushings cause?
16. Which tools are used to pull pilot bushings?
17. In which direction should a pilot bearing be installed?
18. What kinds of problems will a misaligned clutch housing cause?
19. What instrument is used to check clutch housing face and bore runout?

20. Which part of the clutch housing must the indicator stem ride on, when checking the clutch housing bore?
21. How is bore runout corrected?
22. What practices often ruin a clutch repair job?
23. Why must oil leaks into the clutch area be stopped?
24. When should a new clutch disc be installed?
25. In which direction should a clutch disc be installed?
26. How is the clutch disc aligned before installing the transmission?
27. When should a new throwout bearing be installed?
28. Which tool should never be used to seat a throw-out bearing?
29. What is the throw-out fork lubricated with?
30. Why is it important to prevent pressure being exerted on the pressure plate before the transmission is fully in place?
31. What is the advantage of having the throw-out bearing out of contact with the clutch release fingers when the clutch is not depressed?
32. What may be the problem if the pedal sticks or catches before returning to the stop?
33. How much free play should the clutch pedal have?
34. What should a hydraulic clutch linkage be checked for?
35. What is the purpose of subjecting a new clutch to twenty starts?
36. What can happen to a clutch if it is not used for some time after a steam cleaning?
37. How is the clutch dried out after steam cleaning?

M-2

Manual Transmission Service

Objectives: *After completing this assignment, you will be able to—*

1. *explain how to isolate problems in the transmission;*
2. *explain why cleaning the transmission, inside and out, is the most important task in overhauling a transmission;*
3. *explain what to check the gears of the transmission for;*
4. *explain how to install a transmission; and*
5. *explain how to adjust the shift linkage.*

Reference: *Auto Service and Repair,* pp. 535-553.

Exercise:

1. What determines the gear ratios in the first, second, and third gears?
2. What is a transaxle?
3. How is a problem with the transmission pinpointed?
4. What things should you look for when road testing?
5. Why will excessive free travel in the clutch pedal cause shifting to be noisy and difficult?
6. What kinds of repairs can be made on the transmission without removing it?
7. Why is it important to mark the U joints for correct reassembly?
8. What should be done to prevent the roller bearings from falling off the broken U joint of cross-and-roller design?
9. Why should the transmission exterior be thoroughly cleaned?
10. What should the gears, shafts, and synchronizers be checked for?
11. Why is it necessary to get all parts and the inside of the housing absolutely clean?
12. What should the clutch pilot bearing be checked for?
13. What should the drive gear be checked for?
14. What should each roller bearing be checked for?
15. In which direction should the seal lip face in the transmission when the seal is being replaced?
16. Describe the appearance of good output shafts and gears.
17. What should every tooth on every gear be checked for?

18. Describe the condition of good snap ring grooves.
19. Name three ways of securing a countershaft.
20. What is the purpose of the antilash plate on the countergear?
21. In what order should the transmission gears be reassembled?
22. Which parts should be replaced as new parts?
23. How should the parts be treated before installation?
24. How are the thrust washers held in place while the reverse idler gear is installed?
25. How are needle bearings for reverse idler gears and countergears held in place during installation?
26. Why is it important to keep the input shaft and output shaft from separating once they have been mated?
27. What should be done to all fasteners that pass through and into the case?
28. In what position should the transmission and cover be when installing the shift cover?
29. What should be used to align and support the transmission during installation?
30. In what position should the gearshift and transmission be when adjusting shift linkage?
31. What should you look for when road testing a newly repaired transmission?

M-3

Overdrive and Four-Wheel Drive Service

Objectives: *After completing this assignment, you will be able to—*

1. *explain how to work on an overdrive without removing it from the vehicle;*
2. *explain what conditions to look for when examining the parts of an overdrive;*
3. *explain the importance of clean parts when overhauling an overdrive; and*
4. *explain how a transfer case permits four-wheel operation.*

Reference: *Auto Service and Repair,* pp. 553-563.

Exercise:

1. What causes most problems with overdrives?
2. What must be done in order to work on the overdrive without removing the transmission?
3. What would happen if the adapter plate were to move away from the transmission?
4. What conditions should all gear teeth be checked for?
5. What conditions should the clutch rollers be checked for?
6. What should the clutch cam roller surfaces be checked for?
7. What should happen when the balk ring is pressed on one end in a direction that would tend to close the ring?
8. Why should the overdrive be engaged and disengaged a couple of times when checking the oil level of a transmission that has a constant drive overdrive?
9. Why should the sliding clutch of a constant drive overdrive not be washed in a solvent?
10. What should the parts of the constant drive overdrive be cleaned with?
11. What is the purpose of a transfer case?
12. Which gears in the transfer case provide the high and low gear ratios?
13. Which part of the transfer case is splined to the output shaft?
14. Trace the flow of torque from the transmission output shaft to the sliding clutch.
15. How are the front wheels engaged?
16. Why does operating a four-wheel drive on dry, hard surfaces develop internal stresses in a drive train?

17. What addition to the transfer case allows the four-wheel drive to be in operation at all times without damage to the drive train?
18. Why is a limited slip differential used?
19. Where is information available for disassembling and repairing transfer cases?

M-4

Automatic Transmission Checks

Objectives: *After completing this assignment, you will be able to–*

1. name the primary components of an automatic transmission;
2. explain how excessive or inadequate amounts of fluid affect the transmission;
3. explain how to check the origin of leaks; and
4. name the problems that can be identified by checking the fluid on the dipstick.

Reference: *Auto Service and Repair,* pp. 575-582.

Exercise:

1. Why is it impossible to cover complete transmission and service repair in the text?
2. Why does the text cover only in-car service and diagnosis?
3. What are the primary components of a typical transmission?
4. What is the purpose of "lock-up" automatic transmissions?
5. What problems can result from aeration caused by too much fluid?
6. What problems can too little fluid cause?
7. What should be checked, other than fluid level, when the dipstick is removed?
8. How does water in the transmission fluid affect its color?
9. How can you determine whether to make periodic transmission fluid changes?
10. How is the pan drained if there is no drain plug?
11. Where are the potential sources of leaks in a transmission?
12. What methods can be used to distinguish between engine oil and transmission fluid?
13. Why should dirt be removed from the transmission when checking for leaks?
14. Which leaks usually mean that the transmission should be removed?

M-5

In-Car Transmission Repair

Objectives: *After completing this assignment, you will be able to--*

1. *explain how to repair porous castings and rear seals;*
2. *explain how to adjust shift linkage;*
3. *explain how to make the stall test; and*
4. *explain how to check the bands and clutches after the control valve body has been removed.*

Reference: *Auto Service and Repair,* pp. 582-592.

Exercise:

1. What is used to repair a porous casting?
2. What is used to clean a porous casting?
3. In which direction should a seal lip face when installing a new rear seal?
4. What causes shift linkage to become out of adjustment?
5. In which position should the transmission be when adjusting the shift linkage?
6. Why is it critical that the throttle linkage be adjusted correctly?
7. Why is it important to use a special bending tool to bend the TV lever?
8. What is the purpose of the evacuated bellows in the vacuum control?
9. From what point are many throttle linkage adjustments made?
10. What is the purpose of the anti-stall throttle return dashpot?
11. In which positions should the engine crank?
12. How is the stall test made?
13. What kinds of problems are determined by the stall test?
14. Why should the throttle not be kept in the full throttle position for more than 5 seconds?
15. What should be done if the engine exceeds specifications during the stall test?
16. What pressure checks are made while road testing?
17. When will a vacuum gauge be used to check transmission vacuum pressures?
18. What will harsh engagement during selector lever movement through all drive ranges mean?
19. What should be checked when doing the road test for shifting speeds?

20. Why is it important to follow the manufacturer's instructions on each individual transmission when making band adjustments?
21. What do general band adjustment procedures require?
22. Under which part of the transmission is the crossmember that supports the rear of the transmission?
23. What must be done before removing the control valve body?
24. How can you tell if the front clutch is functioning by applying air pressure?
25. How can you tell if the band servo is working by applying compressed air?

M-6

Transmission Removal

Objectives: *After completing this assignment, you will be able to–*

1. *explain the procedure for removing and installing a transmission;*
2. *explain the precautions to take when removing and installing a transmission;*
3. *explain how to flush an oil cooler and lines;*
4. *explain the precautions to take when handling aluminum castings; and*
5. *explain the procedures for towing a vehicle with an automatic transmission.*

Reference: *Auto Service and Repair,* pp. 592-597.

Exercise:

1. Why should the converter and drive plate be marked before disassembly?
2. Why should you *never* pry on the ring gear teeth in order to rotate the drive plate?
3. What care should be exercised when placing a jack under the engine?
4. What is used to support the transmission during disassembly?
5. What is used to prevent the converter from falling off during transmission removal or installation?
6. Which part must you be careful not to place any weight on during transmission removal or installation?
7. What is the purpose of flushing the oil cooler?
8. What is used to flush the oil cooler?
9. What should be checked for if oil seems to be impeded from flowing through the lines?
10. What should be done if the oil cooler is clogged?
11. Why do aluminum castings require special handling?
12. What is used to prevent stripping the threads?
13. What is done to prevent galling the threads?
14. In which range is a vehicle started by pushing?
15. At what speed should the selector lever be placed in low range for starting?
16. Generally, what is the maximum speed for towing a vehicle with an automatic transmission?

M-7

Propeller Shaft and Universal Joint Service

Objectives: *After completing this assignment, you will be able to–*

1. *explain how torque is absorbed in the torque tube and Hotchkiss drive;*
2. *explain the importance of keeping the U joint in the correct plane;*
3. *explain how to disassemble and repair U joints;*
4. *explain how to reassemble the U joints and propeller shaft; and*
5. *explain how to adjust the angle of the transmission and differential.*

Reference: *Auto Service and Repair,* pp. 599-611.

Exercise:

1. What two purposes are served by the torque tube drive?
2. Where are the drive force and axle housing windup handled in the Hotchkiss drive?
3. What is the purpose of the slip yoke?
4. Name five ways of retaining the cross rollers.
5. What is the advantage of the ball-and-trunnion universal joint?
6. What is the purpose of the centering socket between the joints of a constant velocity universal joint?
7. Why should you never place a bar between the cross and yokes to hold the propeller shaft?
8. Why should the parts of the universal joint be marked before disassembly?
9. What can result from misalignment of the planes of the two ends of the propeller shaft?
10. Under what condition can misalignment of the planes result?
11. What should be done to retain the rollers on the cross?
12. Why should a propeller shaft not be allowed to hang by a U joint at one end?
13. What should be done to protect a slip yoke when it has been removed from the transmission output shaft?
14. What may need to be done to prevent the transmission from leaking fluid while the yoke is removed?
15. What should be done to protect the U joint when it is being held by a vise?
16. What kind of hammer is used to drive the cross from the yoke?

17. Why is it better to replace U joints that are only slightly worn than to keep them?
18. What should be used to drive the new retainers in place?
19. What kind of lubricant is used for U joints?
20. What should be used to press the rollers flush with the yoke?
21. How deep should the rollers be driven into the yoke?
22. Why is it important to drive the roller until it is in firm contact with the snap ring?
23. What should be done if the U joint has a bind in it that cannot be removed by striking it with a soft hammer?
24. Why should the tube portion of the propeller shaft not be placed in a vise?
25. Describe a constant velocity U joint.
26. What should be done if the trunnion pin or body raceways of a trunnion universal joint are worn?
27. Why is it important to support the propeller shaft during installation?
28. What is the significance of the arrows or punch marks on a propeller shaft that has a splined stub?
29. What will result from torquing U bolt nuts too tight?
30. Why should a propeller shaft be covered when undercoating a car?
31. What conditions should be ignored when checking the propeller shaft for runout?
32. What should be done to correct vibrations in the propeller shaft when the shaft is in balance?
33. What are the two methods of checking the propeller shaft drive angle?
34. How may the transmission angle be raised or lowered?
35. How may the differential housing angle be changed?

M-8

Troubleshooting and Disassembling the Axle and Housing

Objectives: *After completing this assignment, you will be able to—*

1. *describe the typical automotive drive axle assembly;*
2. *describe the noises made when different components of the drive axle assembly are worn;*
3. *explain how to repair pinion flanges with nicks and burrs;*
4. *explain how to determine the correct preload on wheel bearings; and*
5. *explain how to install wheel bearings and axles.*

Reference: *Auto Service and Repair,* pp. 615-626.

Exercise:

1. Describe a typical automotive drive axle assembly.
2. What are the two types of differential carriers?
3. What should be checked before road testing for drive axle assembly problems?
4. What should the road test involve, as far as the engine is concerned?
5. Which factors can produce sounds that may be confused with drive axle problems?
6. Distinguish between the sounds made by bearings and those made by gears.
7. Describe the sound of defective rear wheel bearings.
8. How can ring and pinion noise be determined?
9. When will differential pinion and side gear noise be noticeable?
10. What is used to measure the preload on the pinion shaft bearings?
11. What tools should not be used to hold the pinion companion flange when removing the retaining nut?
12. How should new leather seals be treated before installing them?
13. How are nicks and burrs removed from the pinion flange?
14. Why should a flange never be pounded into position?
15. What are two methods used to determine the preload on the pinion bearings?
16. What is used to pull a flanged end axle from the bearings?

17. Why is it important to keep the brake backing plate in position while the axle is being removed?
18. What is used to remove a wheel hub or hub-drum from a tapered end axle?
19. What should be done with the brake backing plate and shims while removing a tapered end axle?
20. Why is it important to examine both ends of a broken axle by placing the parts together?
21. Why is it important to remove every single piece of broken axle from the differential housing cavity?
22. In which instances will an oil seal be placed on each side of an axle bearing?
23. What should be used to protect the axle when using a cold chisel to remove the retainer ring?
24. On which race is pressure exerted when installing the bearing on the axle?
25. Why is it important to check the length of the axles before installing them?
26. Why is it important to align the gasket oil hole correctly when installing the axle?
27. What three factors control axle end play?
28. Explain the procedure for torquing an axle nut to specifications.
29. In which direction should the nut be turned to align the axle cotter pin hole with the castellations?

M-9

Differential Disassembly and Repair

Objectives: *After completing this assignment, you will be able to—*
1. explain the procedure for disassembling a differential and
2. explain the procedure for repairing a differential.

Reference: *Auto Service and Repair,* pp. 626-642.

Exercise:

1. What should be done before removing the differential case side bearing caps?
2. What is used to lift a shim-adjusted preload differential out of the housing?
3. What should be done with the shims?
4. What is the maximum distance the spreader should open the differential housing?
5. How is the ring gear removed from the case?
6. How are the pinions removed from the case?
7. In what condition must the case side bearing contact surfaces be?
8. What instrument is used to check the differential case for runout?
9. How are the pinion gears aligned with the shaft hole?
10. How can the ring and pinion gears be checked to see if they are a matched set?
11. What should the case flange and attaching surface of the ring gear be checked for before installing them?
12. What is used to align the ring gear with the differential case?
13. What is the correct procedure for tightening the ring gear fasteners?
14. Why is it necessary to have the correct number of teeth on the ring and pinion gears?
15. What should be done with shims as they are removed from the pinion drive gear?
16. What should all parts of the pinion drive gear assembly be checked for after it is disassembled?
17. On which part should pressure be exerted when installing bearings on a pinion shaft?
18. What indicates the distance a pinion should be set from the center line?
19. How can you tell when to add or remove shims from a pack?

20. What are two methods of setting the preload?
21. What is the difference between the nonhunting and hunting types of pinion gears?
22. What is used to set the backlash between the ring gear and pinion gear?
23. What kind of wrench is used to turn the adjusters?
24. What should be done if the backlash varies more than the specified allowable variation at four points around the ring gear?
25. What tool is used to install the preload shims?
26. What is the procedure for checking the contact pattern after the paste has been applied to the ring gear?
27. Describe the pattern that should exist on the ring gear.
28. What causes a heel contact pattern, and how is it corrected?
29. What causes a face contact pattern, and how is it corrected?
30. What friction members are used to limit slip when one wheel attempts to spin?
31. What methods are used to apply pressure to the friction members of a limited slip differential?
32. What precaution should be exercised when selecting the lubricant for a traction-type differential?
33. What is the purpose of the vent in the differential?

Section

N

Suspension Service

N-1: Brake System Operation
N-2: Repairing Drum Brakes
N-3: Repairing Disc Brakes
N-4: Wheel Alignment
N-5: Front Wheel Bearings
N-6: Tire Service
N-7: Manual Steering Systems
N-8: Power Steering Systems
N-9: Steering Linkage

N-1

Brake System Operation

Objectives: *After completing this assignment, you will be able to—*
1. explain how air is kept from being drawn into the system;
2. explain the conditions that the brake system should be checked for;
3. explain the function of the parts of the brake system; and
4. name the three kinds of wheel cylinders.

Reference: *Auto Service and Repair,* pp. 647-657.

Exercise:

1. What is the purpose of maintaining a residual pressure in the hydraulic lines?
2. What are the two functions served by the bleeder holes in the head of the piston?
3. Why is it important that you not breathe asbestos particles from the brake linings?
4. What kind of feel of the brake pedal indicates that air is in the system?
5. Explain how to determine whether or not the vacuum booster is working.
6. What conditions on one brake indicate that the other three wheels should be removed for inspection?
7. How should the wheel cylinders be checked for leakage?
8. What should the brake drums be checked for?
9. What should disc rotors be checked for?
10. What should the chassis be checked for?
11. Describe the conditions under which the vehicle should stop during a braking test.
12. Why is the single-piston master cylinder no longer installed in new vehicles?
13. What makes the double-piston master cylinder safer than a single-piston master cylinder?
14. Where should the fluid level of a master cylinder be?
15. Why is the cover supplied with a vent?
16. What is indicated if the pedal does not stay firm but moves slowly downward?
17. What will happen if the compensating port is stopped up?
18. What conditions are indicated by excessive brake pedal travel?
19. How can the check valve be tested?

20. What should be used to clean brake parts?
21. What conditions make a master cylinder useless?
22. What should be used to remove scratches and corrosion?
23. What kind of gauge is used to check the cylinder for wear?
24. Why must the compensating port be free of burrs?
25. What should the parts be lubricated with before installation?
26. When should fluid be put in the master cylinder and all air bled from it?
27. How is all of the air purged from the master cylinder after it is installed?
28. What is the purpose of the free travel of the pedal?
29. What are the two reasons for power boosters?
30. How can the vacuum be checked for leaks?
31. What should the rubber parts of the booster be cleaned with?
32. What are three typical wheel cylinders?

N-2

Repairing Drum Brakes

Objectives: *After completing this assignment, you will be able to–*

1. *explain the procedure for removing the master cylinder and disassembling it;*
2. *explain how to repair and reassemble the master cylinder;*
3. *explain how to remove and disassemble the wheel cylinders;*
4. *explain how to repair and reassemble the wheel cylinders; and*
5. *explain how to adjust the parking brakes.*

Reference: *Auto Service and Repair,* pp. 657-673.

Exercise:

1. Why should the brake line on the rear wheel not be bent out of the way during removal of the wheel cylinder?
2. What is used to force the piston out of a single end cylinder?
3. Why should iron wheel cylinder pistons not be washed?
4. What should be used to remove scratches and pitting in the wheel cylinder?
5. What kind of finish in wheel cylinders should not be honed?
6. What is the maximum clearance allowed between the cylinder and piston?
7. Why do many shops refuse to overhaul wheel cylinders?
8. In which direction should the new cups be installed?
9. What are the five steps in repairing wheel cylinders?
10. Why should the wheel cylinders be reconditioned when the brakes are relined?
11. What is a servo brake?
12. What makes a brake shoe self-energizing?
13. Which of the shoes in figure 29-26 is self-energizing in forward gear?
14. What kind of brakes are self-centering?
15. Why is a wheel cylinder clamp used?
16. What tool is used to remove the brake retracting springs?
17. What conditions indicate that springs are unfit for use?
18. Why do most shops not reline brakes?

19. Name six conditions that should not exist on shoes that are to be relined.
20. How are old rivets removed?
21. What kind of rivet set is used?
22. How long should the rivet be?
23. Why should a new shoe be ground?
24. Why are concentric ground shoes seldom used?
25. What is an eccentric ground shoe?
26. How should the shoe pads be treated?
27. Why should the shoe cam adjusters be cleaned and backed off?
28. How can you recognize the primary shoe and its proper position?
29. Why must even the slightest bit of oil be kept from the face of the lining?
30. Where is the adjustment slot for manual adjustment located?
31. Explain the procedure for making manual brake adjustment.
32. Which kind of brake design requires major brake shoe adjustment?
33. Explain the process for centering shoes with a single eccentric anchor.
34. What tool is used to make the initial adjustment for self-adjusting brakes?
35. How many notches should the star wheel be backed off after a firm drag is felt when making the initial adjustment of self-adjusting brakes by the hand method?
36. What should be used to wipe dust from the brake drum?
37. What is the maximum amount a car brake drum can be oversized?
38. What is the greatest variance in size that is allowed between the two front brake drums?
39. How are drums trued?
40. How much clearance should be allowed for an external type of drive shaft parking brake?
41. What should be done before adjusting the cable of the internal type of drive shaft parking brake?
42. Explain the procedure for adjusting the rear wheel type of parking brakes.
43. What kind of brake fluid should be used?
44. Explain the procedure for bleeding the brake system manually.
45. When bleeding tandem master cylinders, which wheels should be bled first?

N-3

Repairing Disc Brakes

Objectives: *After completing this assignment, you will be able to—*
1. explain how to remove and disassemble disc brakes;
2. explain how to repair and reassemble disc brakes; and
3. explain the function of the metering valve, pressure differential switch, and the combination valve.

Reference: *Auto Service and Repair,* pp. 674-680.

Exercise:

1. What is used to draw the pad from contact with the rotor?
2. Explain how a fixed caliper disc brake works.
3. Explain how the floating caliper disc brake works.
4. When should the pads be replaced?
5. What should be done before forcing the piston back into the bore?
6. What should the pistons and boots be checked for once the pads are removed?
7. What can be used to help remove the piston from the bore?
8. What precautions should be taken when using air pressure?
9. What is used to remove the cylinder seal?
10. What is used to clean the caliper and parts?
11. What is the most a cylinder can be increased in bore size?
12. How are the boot and seal grooves cleaned?
13. What should the new piston seal be coated with before being installed?
14. What are the piston and cylinder coated with?
15. What can cause the calipers to align in a nonparallel position?
16. How deep is scoring permissible?
17. What is the maximum permissible lateral runout on the rotor?
18. What is the maximum amount the two surfaces of the disc may be out of parallel?
19. Why must discs be resurfaced in pairs?
20. List ten disc brake cautions.
21. What is the purpose of the proportioning valve?
22. What is the function of the metering valve?
23. What is the purpose of the pressure differential switch?

N-4

Wheel Alignment

Objectives: *After completing this assignment, you will be able to–*

1. *explain what is meant by the term* wheel alignment;
2. *explain the conditions under which wheel alignment should be tested;*
3. *explain how settings of caster and camber will affect the handling of a vehicle;*
4. *explain why correct toe-in is critical; and*
5. *explain how toe-out on turns is achieved.*

Reference: *Auto Service and Repair,* pp. 689-700.

Exercise:

1. What does wheel alignment refer to?
2. What problems may improper alignment cause?
3. Which of the alignment angles are adjustable?
4. Why should the suspension system be checked before aligning the wheels?
5. What is curb weight?
6. What is curb height?
7. Where should the point of greatest runout be when making checks?
8. What is the difference between positive caster and negative caster?
9. How may caster be set to allow for the normal crown on most roads?
10. What problems are caused by improper caster?
11. What is camber?
12. Explain the difference between positive and negative camber.
13. Why do many makers of automobiles recommend that the left wheel have a ¼ to ½ degree more positive camber than the right wheel to compensate for normal road camber (crown)?
14. Why are caster and camber usually checked and adjusted together?
15. List the five methods of adjusting caster and camber.
16. What is steering axis inclination?
17. How does the steering axis inclination affect steering?

18. What is the purpose of toe-in?
19. Why is toe-in a critical setting?
20. How should the steering wheel be set during toe-in adjustment?
21. How can the steering wheel be adjusted to the correct position?
22. Why are steering systems designed to have toe-out on turns?
23. How is toe-out on turns provided for?
24. What can cause the rear wheels to track incorrectly?
25. When should a road test be made?

N-5

Front Wheel Bearings

Objectives: *After completing this assignment, you will be able to—*
1. name the two types of front wheel bearings;
2. explain how to remove front wheel bearings from the hub;
3. explain how to service the bearings;
4. explain why roller cones are designed to "creep"; and
5. explain how to properly adjust front wheel bearings.

Reference: *Auto Service and Repair,* pp. 700-707.

Exercise:

1. Name the two types of front wheel bearings, and tell which type is preferred.
2. Why do some mechanics prefer to remove the tire and wheel before removing the hub?
3. What is used to remove the inner roller bearings?
4. What conditions render bearings useless?
5. What should also be replaced if the roller and cone assembly is defective?
6. What should be used to remove the cups from the hub?
7. What should be done before packing a bearing with grease?
8. In what condition must the bearings be before they may be packed with grease?
9. What is the purpose of coating the hub and dust cap with grease?
10. How much grease should be applied to the hub?
11. Under what conditions should a crack-detecting solution be applied to the spindle?
12. Why are the roller cones designed to "creep" around on the spindle?
13. How must the inside of the cone and the area of the spindle engaged by the cone be treated?
14. How should new grease seals be treated before installation?
15. How deep are seals usually set in the hub?
16. Why must the seal be struck only on the outside edge?
17. What problems can improper wheel bearing adjustment cause?
18. What is the purpose of setting a heavier initial torque than the final torque setting?

19. How much end play should be allowed when adjusting with the dial indicator method?
20 What wear may be confused with wheel looseness?
21. How much end play should ball bearings be adjusted for?
22. What should be done to eliminate brake friction pads from interfering with bearing adjustment?
23. Why is it important that all end play be removed during bearing adjustment?
24. Which part should be between the adjusting nut and the bearing cone?

N-6

Tire Service

Objectives: *After completing this assignment, you will be able to—*

1. *explain how to read tire sizes;*
2. *explain the kinds of wear from overinflation and underinflation;*
3. *explain how to recognize the wear caused by improper alignment; and*
4. *explain how to balance the rear wheels at the correct engine speed.*

Reference: *Auto Service and Repair,* pp. 707-713.

Exercise:

1. What does each number and letter refer to in the size "H78-15"?
2. What materials are used as cord materials?
3. What are three types of cord construction?
4. What problems result from underinflating a tire?
5. Where does an overinflated tire wear most?
6. When should tires be checked for pressure?
7. How often should tires be rotated?
8. How should radial tires with a spare be rotated?
9. How should conventional tires be rotated?
10. What is the preferred way to repair punctures?
11. Why should you stay away from the tire while inflating?
12. What is the maximum pressure to use to force the beads to seat against the rim?
13. What kind of wear will improper toe-in cause?
14. What usually causes cupped out spots on a tire?
15. How do the problems caused by static and dynamic balance differ?
16. Why is it important that a wheel not have excessive lateral or radial runout?
17. When balancing the rear wheels, with one held stationary and the other free to turn, why should you not exceed a speedometer reading of 40 mph?

N-7

Manual Steering Systems

Objectives: *After completing this assignment, you will be able to–*

1. explain how the steering gearbox is connected to the vehicle and steering system;
2. explain how the preload on the bearings and over-center adjustments are made; and
3. explain the disassembly and repair procedures for the gearbox.

Reference: *Auto Service and Repair,* pp. 719-725.

Exercise:

1. What are the components of a manual steering system?
2. What problems can result from using a lubricant that is too thick in the steering gearbox?
3. How is the gearbox serviced if it has no filler plug?
4. What is the average gear ratio in the manual steering gear that uses the recirculation ball worm and nut design?
5. What is usually used to connect the steering gearbox to the steering shaft?
6. What is done to remove the preload caused by the meshing of the ball nut and pitman sector teeth in the center travel position?
7. Why should the steering wheel be turned carefully when the pitman arm is disconnected?
8. Where is the worm shaft bearing adjuster found?
9. What tool is used to measure the preload on the worm bearings?
10. What is the over-center adjustment?
11. Which part makes the over-center adjustment?
12. Where will the greatest pull be when checking the over-center adjustment?
13. Why should there be a little play between the sector and ball nut teeth in the extreme positions?
14. Which instrument may be recommended to replace a torque wrench when checking the over-center adjustment?
15. Why should the steering gear assembly be held horizontal when removing the worm shaft and ball nut?
16. What must be done to remove the ball nut from the shaft?

17. Why must all parts showing noticeable wear or damage be replaced?
18. Explain the procedure for installing the balls.
19. What precaution should be taken before tightening the cover fasteners?

N-8

Power Steering Systems

Objectives: *After completing this assignment, you will be able to—*
1. explain how the linkage and integral power steering systems work;
2. explain how to make the three power steering adjustments;
3. explain what produces the worm to rack-piston preload;
4. name the three types of power steering pumps; and
5. explain how to check the power steering pump belt tension.

Reference: *Auto Service and Repair,* pp. 725-738.

Exercise:

1. Where is the power cylinder located in a linkage-type power steering system?
2. What causes the control valves to open on the linkage-type power steering system?
3. Which parts of the linkage type are eliminated in the self-contained power steering system?
4. Why is the in-line design so named?
5. Which part serves as the power piston in the in-line type?
6. What are the three basic adjustments of the in-line power steering gear?
7. Which is the most critical adjustment as far as car handling is concerned?
8. How is fluid removed from the reservoir when removing the power steering unit?
9. Which part is used to adjust the preload on thrust bearings?
10. What is the procedure for testing the worm to rack-piston preload?
11. What produces the mild worm to rack-piston preload?
12. How is the worm to rack-piston preload increased?
13. What size arc should be used in checking the pitman shaft over-center preload?
14. Why is it so important to keep the work area, tools, and hands clean?
15. What problems will steering gear misalignment cause?
16. How is the wheel spoke position adjusted?
17. What are the three types of power steering pumps?
18. What do all three types of pumps have in common?

19. What holds the vanes against the ring walls?
20. What kinds of problems require that the pump be disassembled for repair?
21. What precaution should be exercised when disassembling a pump?
22. What kind of excessive wear should be checked for?
23. What should be used to prevent damage to O rings when reassembling the pump?
24. What repair can be done on-the-car?
25. What should the power steering belts be checked for?
26. What should the power steering hoses be checked for?
27. What are the three major factors involved in a power steering pressure test?
28. What is the maximum length of time the steering wheel should be held hard against the stops?
29. What are three ways to check the power steering belt tension?
30. What is the most accurate method of testing belt tension?

N-9

Steering Linkage

Objectives: *After completing this assignment, you will be able to–*

1. *name and identify the parts of the suspension system;*
2. *explain how to disassemble the parts of the suspension system;*
3. *give the precautions to take while working on the suspension system;*
4. *explain how to check the parts of the suspension system; and*
5. *explain how to repair the suspension system.*

Reference: *Auto Service and Repair,* pp. 738-754.

Exercise:

1. What is used to remove the pitman arm from the pitman shaft?
2. What is done to assist the torque in seating the pitman arm on the pitman shaft?
3. When should a power removing tool, such as shown in figure 31-55, be used?
4. Which adjustment does the tie rod adjuster sleeve make?
5. Where are the sleeve clamps placed?
6. What are the two ways of correcting a worn idler arm?
7. What are the three methods of springing the front end?
8. What is the purpose of the coil spring or rubber pressure ring in non-load-carrying ball joints?
9. What are the two types of loads placed on ball joints?
10. What kinds of problems will excessive ball joint wear cause?
11. How are the ball joints unloaded when the coil spring is mounted between the lower suspension arm and the frame?
12. How are the ball joints unloaded when the coil spring is placed between the top suspension arm and the car body?
13. What is the *axial movement* used to check ball joint wear?
14. What is the *sidewall movement* used to check ball joint wear?
15. Why is it necessary to place jacks or jack stands under the lower control arm when the coil spring is mounted between the lower arm and the frame?
16. How is the ball joint removed from the suspension arm after the nut is removed?

17. Why should you never try to force the ball stud out with a special removal tool?
18. How is a tension-loaded main ball joint removed after the nut is removed?
19. List four methods of securing ball joints to the suspension arm.
20. What kind of bolts should be used to secure ball joints to the suspension arm?
21. What kind of adjustment may be made by an eccentric in the upper ball stud?
22. What is the function of a spring compressor?
23. List the three steps that may be required to remove all tension from a torsion bar.
24. Why should all nicks be removed from the torsion bar before installing it?
25. How is the correct tension on the tension bar determined?
26. How can you avoid ruining the caster and camber adjustments when removing the suspension arm mounting shaft?
27. What rule should be followed when replacing suspension arm bushings?
28. What should the suspension arm be checked for after cleaning?
29. Why should a spacer be used when removing and installing bushings?
30. What functions are served by shock absorbers?
31. Which actions of the spring does a shock absorber control?
32. How does the shock absorber provide a damping action to the movement of the vehicle?
33. How should leaking shock absorbers be corrected?
34. How many "free" bounces do good shock absorbers allow when the corner of the vehicle is bounced?
35. What should be done if the nut holding the shaft of a shock absorber is frozen?
36. What is the average life of a shock absorber, in miles?
37. What kind of rear springs do American-made cars generally use?
38. Why should the vehicle be at normal standing height before tightening bolts to rear suspension arms or track bars?
39. What should you do before torquing shackle bolts of rear leaf springs?

Section

O

Air-Conditioning System Service

O-1: How Air Conditioning Works
O-2: Air-Conditioning Service

O-1

How Air Conditioning Works

Objectives: *After completing this assignment, you will be able to—*
1. explain the functions of the parts of the air-conditioning system
2. explain the refrigeration cycle.

Reference: *Auto Service and Repair,* pp. 763-769.

Exercise:

1. What is accomplished in the basic air-conditioning process?
2. At what temperature will Refrigerant-12 boil at sea level?
3. What is the purpose of raising and lowering the pressure on Refrigerant-12?
4. Where does the high-pressure refrigerant collect?
5. Which part reduces the pressure of the refrigerant?
6. In which part does the low-pressure refrigerant turn into low-pressure vapor?
7. Which part controls the temperature of the evaporator?
8. How much pressure does the compressor develop in the vapor as it passes to the condenser?
9. What causes the hot refrigerant vapor to change into a liquid?
10. What is the function of the receiver-dehydrator?
11. How does the condition of the refrigerant change as it passes through the expansion valve?
12. Which parts regulate the amount of refrigerant the expansion valve allows to pass into the evaporator?
13. What action by the refrigerant allows it to absorb heat from the tubes and cooling fins?
14. What causes the dehumidifying action in the stream of air?
15. How does the thermostatic switch prevent icing?
16. How does a suction throttling valve or POA valve prevent icing?
17. What is the advantage of the POA valve over the suction throttling valve?
18. What does the axial type of compressor use in place of a crankshaft?
19. What is meant by *double-acting* pistons?
20. What kind of clutch drives the compressor?

21. What is the function of the condenser?
22. Where is the condenser located?
23. At what temperatures do condensers operate?
24. Where are mufflers located?
25. Why should mufflers be installed with the outlet side down?
26. What is the purpose of lowering the refrigerant pressure as it passes into the evaporator?

O-2

Air-Conditioning Service

Objectives: *After completing this assignment, you will be able to—*

1. *list the safety precautions to be exercised when charging a system;*
2. *explain the key points to remember when disassembling and assembling a system;*
3. *explain the method for determining the correct vacuum reading during evacuation;*
4. *explain how to discharge and to charge a system; and*
5. *list five methods of checking a system without test equipment.*

Reference: *Auto Service and Repair,* pp. 769-782.

Exercise:

1. What should you do if Refrigerant-12 is allowed to contact your eyes?
2. Why should the refrigeration system never be steam-cleaned?
3. Why should you avoid breathing the smoke produced when Refrigerant-12 contacts a flame?
4. What are the only two components allowed inside an air-conditioning system in order for it to function as designed?
5. What problems can air, dirt, or moisture in the system cause?
6. What should be used to clean the outside of fittings?
7. Why should refrigerant lines be close to room temperature before disconnecting?
8. What should be done immediately after disconnecting a line?
9. What should be used to flush contaminated parts?
10. What should be done before opening a connection?
11. What is the minimum radius for hose bends?
12. Why must fittings be coated with refrigeration oil before assembly?
13. What does a manifold gauge consist of?
14. Where are the service (Schrader) valves located?
15. What should be used to divert any escaping refrigerant when connecting gauge lines to the Schrader valves?
16. In what position should manifold gauge valves be before connecting gauge lines to Schrader valves?

17. What kind of connection is used if no Schrader valves are used?
18. What action may be taken when the hand shutoff valve is in the halfway open position?
19. List the six steps that must be taken when a part must be removed from the system.
20. What are two methods for checking leaks?
21. How is pressure developed in the system to test for leaks?
22. What does the color of the Halide torch flame indicate about the size of the leak?
23. How should the manifold gauge be connected to the system?
24. Why should the system be discharged slowly?
25. What should be connected to the center hose of the manifold gauge when evacuating the system?
26. How many inches of vacuum should the vacuum pump draw at sea level?
27. How long should the vacuum be held before making a leak test?
28. What should be done with the partial charge after the test?
29. In what condition should the system be after the final evacuation?
30. How is oil lost from the system?
31. What will result from the incorrect amount of lubricating oil in the system?
32. Where are most two-cylinder compressors checked for oil?
33. Where is an injector connected to add oil without discharging the system?
34. What are five simple checks to make before making a full-scale system analysis?

Section

P

Exhaust and Emission Control System Service

P-1: Exhaust and Emission Control System Service

P-1

Exhaust and Emission Control System Service

Objectives: *After completing this assignment, you will be able to–*
1. explain the function of each of the emission control systems and
2. explain how each of the emission control systems operates.

Reference: *Auto Service and Repair,* pp. 789-811.

Exercise:

1. What is the only periodic service that a manifold may need?
2. What may be needed, in addition to wrenches, to remove fasteners from the manifold?
3. What tool is used to remove burrs and bits of gasket from a manifold?
4. Why should the fasteners be retorqued after the engine has been in operation?
5. What does the heat control valve do during engine warm-up?
6. What is the function of the exhaust pipe?
7. What are the three basic muffler designs?
8. What are mufflers made of?
9. What is the advantage of using an electric pipe joint heater?
10. Why is a chain wrench useful in removing and installing tail pipes?
11. What should be done if a tail pipe cannot be removed from a muffler?
12. How should the joint between the muffler nipple and the tail pipe be treated?
13. Why is the depth the tail pipe is inserted into the muffler so important?
14. What may be needed to remove the muffler, other than wrenches?
15. Where is the alignment of the tail pipe particularly important?
16. What are the two methods of correcting a faulty catalytic converter?
17. What is the purpose of the internal engine emission controls?
18. What is the purpose of the external engine emission controls?
19. What is the purpose of the fuel system vapor emission controls?
20. How does the PCV system work?
21. How does the air injection system work?

22. What kind of pump is used to inject air into the exhaust system?
23. How is the pump intake air filtered?
24. Where is the air injected into the exhaust system?
25. What prevents the engine from backfiring when the fresh air mixes with the unburned fuel in the exhaust system?
26. What should be used to adjust tension when adjusting the pump belt?
27. How is the check valve checked to see if it will open and return to a closed position?
28. How is the diverter valve checked?
29. Why should compressed air never be used to clean the antibackfire or check valves?
30. What is the purpose of recirculating a portion of the burned gases to the combustion chamber?
31. What controls the amount of exhaust gas recirculated?
32. When is exhaust gas not recirculated to the combustion chamber?
33. What is the purpose of a back pressure transducer valve?
34. What should happen to the engine if the EGR valve is good and the EGR diaphragm is depressed with the tip of the fingers?
35. What is wrong if the engine loses no rpm and the idle is rough?
36. What is the purpose of the coolant temperature override switch?
37. Where does the thermostatic air cleaner direct air from, when the engine is cold?
38. Where does the thermostatic air cleaner direct air from, when the engine is warm?
39. What instrument is used to check the correct temperature at which the valve starts to open and when it is fully open?
40. What does the early fuel evaporation system do?
41. What is the purpose of retarding the spark when the engine is warm and operating at a speed above idle?
42. What is the purpose of cracking open the throttle slightly during sudden deceleration?
43. What does the closed loop system do?
44. How does a catalytic converter work?
45. Which type of converter may be repaired without replacing the entire unit?
46. What tools are used to remove the pellets from the converter?
47. What does an evaporation control system usually consist of?